Annual Reports for 1949-51 of the Pathological Division of the Rubber Research Institute of Malaya

RUBBER RESEARCH INSTITUTE OF MALAYA
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PREFACE

IT HAS BEEN THE CUSTOM to publish annually the reports of the several Divisions of the R.R.I. together with an introductory survey by the Director.

During the period of recovery after the war, publication of progress reports was delayed. The reports of the Divisions from September 1945 to the end of 1948 were issued as a single publication. Separate publications on specific subjects of research have continued to appear as Communications to the Journal of the R.R.I., but formal Annual Reports have not been published.

Postwar plans for research and development have crystallised and have been formally embodied in the Malayan Rubber Fund Five Years Plan 1949-53. The work of the R.R.I. since 1948 may therefore be reviewed in relation to the general research programme laid down for the five years.

This individual report is one of a number which together will constitute a general report for 1949-51. The whole may thus be regarded as an interim report on the workings of the five years plan. The numbering of the sections under the chapter heading INVESTIGATIONS is that adopted in the general research programme.

The Reports for 1949, 1950 and 1951 of the Pathological Division are presented.

Director

PATHOLOGICAL DIVISION 1949

RUBBER RESEARCH INSTITUTE OF MALAYA
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STAFF

THE DIVISION WAS AT FULL STRENGTH in senior officers until 22 November, when Mr R.A. Altson proceeded on home leave, and the duties of acting Head of the Division were assumed by the writer. Mr F.W. Hutchison, the title of whose post was changed from Advisory Officer to Field Research Officer with effect from 23 May, Mr R.N. Hilton, the Pathologist, and Mr K.P. John, the Assistant Pathologist, were on duty throughout the year.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENT IS MADE to the Commonwealth Mycological Institute and the Commonwealth Institute of Entomology for their assistance in identifying material. We are also indebted to the Department of Agriculture and Forest Research Institute for the help which they have given in several ways.

INVESTIGATIONS

I

DISEASES OF THE ROOT SYSTEM

Monthly reports received from the Smallholders' Advisory Service recorded root diseases on only 3.8% of the 48,000 holdings visited during the year, as against 5% in 1948.

The manner in which sources of infection arise in stumps of the old stand in a replanting was discussed in our last report*. Experiments described in the first section which follows continue an investigation of the two hypotheses which have been advanced—the one supposing spore infection of previously healthy stumps; the other postulating dormant sources of infection which become active when the tree is felled. Observations having a direct practical bearing on root disease control procedures are described in the second section below.

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I(1) STUDIES CONCERNED WITH THE GROWTH, PATHOGENICITY, AND DISPERSAL OF THE THREE MAJOR ROOT PARASITES

Influence of the age and vitality of the host on the activities of the three major root parasites — The experiment which was put down on the Experiment Station in 1948* has been concluded. The results summarised in TABLE I for *Fomes lignosus*, TABLE II for *Ganoderma pseudoferreum* and TABLE III for *Fomes noxius* are based on four inoculated roots for each observation. Certain inconsistencies, particularly with *G. pseudoferreum* and *F. noxius*, are thought to be due to the unavoidable variability of the inocula.

With regard to the influence of age of host on the activity of the parasites, the evidence presented in TABLES I and III, although not conclusive, suggests that the intact roots of six year old trees were more susceptible to invasion by *F. lignosus* and *F. noxius* than were those of twenty year old trees. Thus, eight months after inoculation *F. lignosus* had penetrated three times as far into the younger roots as it had in the older ones; and whereas *F. noxius* was successfully inoculated into eight out of sixteen of the six year old roots, only one out of sixteen of the twenty year old roots became infected. The observations recorded in TABLE II for *G. pseudoferreum*, to judge by the results four and six months after inoculation and by the total numbers of successful inoculations of intact roots, suggest that the activity of this fungus is not much affected by the age of the host.

It is possible that more marked differences in the effect of age on resistance might have been obtained if trees younger than six years old had been employed in the experiment.

The data in TABLE I demonstrate fairly conclusively that a moribund root, irrespective of its age, is less able to resist penetration by the fungus *F. lignosus* than is an actively growing one. While this finding may explain why the stump of an apparently healthy tree can be invaded so rapidly by *F. lignosus*, the problem as to how such stumps become infected in the first instance remains unsolved; but the relative ease with which intact roots of twenty year old trees have been infected casts doubt on the theory of dormant sources of infection.

Inconsistencies in the results for *G. pseudoferreum* (TABLE II) and *F. noxius* (TABLE III) make interpretation difficult. Out of thirtytwo severed roots inoculated with *Ganoderma*, only five were infected and three penetrated, whereas the comparable figures for

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TABLE I: INFLUENCE OF AGE AND VITALITY OF THE HOST ON THE ACTIVITY OF FOMES LIGNOSUS

Degree of Infection	*Age of roots (yrs)*	*Period after Inoculation*							
		2 months		*4 months*		*6 months*		*8 months*	
		Int	*Sev*	*Int*	*Sev*	*Int*	*Sev*	*Int*	*Sev*
No. of roots infected	6	4	4	4	4	4	4	4	4
	20	4	4	4	4	4	4	4	3
Mean length of epiphytic growth (in)	6	24½	20	37½	20	46	52	41	70
	20	22	29	26	15	52	58½	42½	70
Max. length of epiphytic growth (in)	6	43	32	48	50	60	78	60	126
	20	30	33	48	31	96	96	60	102
No. of roots penetrated	6	1	3	2	2	4	4	3	4
	20	2	3	2	2	1	3	4	3
Mean length of penetratn (in)	6	3	2	7	23	15	19	35	61
	20	2	3	3	5	16	48	12	50

Int = roots intact *Sev = roots severed*

TABLE II: INFLUENCE OF AGE AND VITALITY OF THE HOST ON THE ACTIVITY OF GANODERMA PSEUDOFERREUM

Degree of Infection	*Age of roots (yrs)*	*Period after Inoculation*							
		2 months		*4 months*		*6 months*		*8 months*	
		Int	*Sev*	*Int*	*Sev*	*Int*	*Sev*	*Int*	*Sev*
No. of roots infected	6	0	0	1	1	2	0	3	2
	20	1	2	2	0	2	0	0	0
Mean length of epiphytic growth (in)	6	—	—	15½	23	12½	—	15	55½
	20	5	6	11½	—	14½	—	—	—
Max length of epiphytic growth (in)	6	—	—	15½	23	19	—	23	78
	20	5	9	12	—	20	—	—	—
No. of roots penetrated	6	—	—	1	1	1	—	2	2
	20	0	0	1	—	1	—	—	—
Mean length of penetratn (in)	6	—	—	1	22	6	—	4½	52½
	20	—	—	1	—	3	—	—	—

Int = roots intact *Sev = roots severed*

TABLE III: INFLUENCE OF AGE AND VITALITY OF THE HOST ON THE ACTIVITY OF FOMES NOXIUS

Degree of Infection	*Age of roots (yrs)*	*Period after Inoculation*							
		2 months		*4 months*		*6 months*		*8 months*	
		Int	*Sev*	*Int*	*Sev*	*Int*	*Sev*	*Int*	*Sev*
No. of roots infected	6	1	1	2	0	2	1	3	2
	20	0	2	0	1	0	0	1	0
Mean length of epiphytic growth (in)	6	2	$2\frac{1}{2}$	3	—	6	7	16	4
	20	—	9	—	6	—	—	6	—
Max. length of epiphytic growth (in)	6	2	$2\frac{1}{2}$	6	—	10	7	32	4
	20	—	12	—	6	—	—	6	—
No. of roots penetrated	6	1	1	1	—	2	1	2	1
	20	—	2	—	1	—	—	1	—
Mean length of penetration (in)	6	$\frac{1}{4}$	$\frac{1}{4}$	3	—	4	7	$12\frac{1}{2}$	$3\frac{1}{2}$
	20	—	9	—	12	—	—	12	—

Int = roots intact *Sev = roots severed*

intact roots were eleven and six respectively; yet the three severed roots which were penetrated were invaded at a much greater rate than the corresponding intact ones. The number of roots penetrated by *F. noxius* was about the same in both categories. It is of interest to observe that in one of the four sets of inoculations with this fungus giving comparable results, namely six year old roots examined after eight months, the mean lengths of epiphytic growth and of penetration in the intact roots were four times as great as in the severed ones. It should also be noted that in two cases the length of penetration by *F. noxius* markedly exceeded the length of its epiphytic growth.

That the failure to induce infection was in no instance due to death of the parasite was confirmed by re-isolating it from each infected root fragment used as an inoculum, at the time when the host roots were removed for examination. It may be that the lower degree of infectivity of the *Ganoderma* and *F. noxius* inocula is bound up with the slower growth of these fungi, assuming that the stimulus for rhizomorph production is exhaustion of nutrients in the substrate.

Although the high proportion of negative results obtained with *G. pseudoferreum* and *F. noxius* make it necessary to be cautious in drawing conclusions for these fungi, the experiment has clearly shown that they are less efficient parasites than *F. lignosus*, which is not only the most virulent of the three but also the most vigorous. This is clearly brought out by the figures in TABLE IV, which is a summary of the data in TABLES I, II and III.

TABLE IV: SUMMARY OF DATA PRESENTED IN TABLES I, II AND III

Parasite	*No. of roots infected*		*No. of roots penetrated*		*Maximum recorded epiphytic growth (ins)*		*Greatest mean penetration (ins)*	
	Int	*Sev*	*Int*	*Sev*	*Int*	*Sev*	*Int*	*Sev*
F. lignosus	32	31	19	24	96	126	35	61
Ganoderma	11	5	6	3	23	78	6	52
F. noxius	9	7	7	6	32	12	12	12

Int = roots intact *Sev = roots severed*

Factors affecting the pathogenicity of Fomes lignosus — A start was made last year to study factors affecting the pathogenicity

of *F. lignosus* by means of observations on artificially inoculated seedlings growing in pots in the laboratory*. No progress has been made with these studies because of the difficulty experienced in bringing about infections under laboratory conditions; whether in sterile sand or in soil, and whether inoculated with a pure culture of the fungus or with pieces of diseased root, no infections have occurred.

Relation of the spores of Fomes lignosus to the spread of root disease — Observations have been started both on the Experiment Station and in the laboratory to investigate the part played by spores of *F. lignosus* in the spread of root disease.

The field observations were made to determine whether spores discharged from fructifications, or contained in fras which fell from them, could bring about infection of rubber roots. Short sections of washed healthy roots were buried in sterilised soil at a depth of about four inches in five 10-inch pots, with one piece placed vertically so as to protrude above soil level. For two months the pots were kept beneath actively growing fructifications that had developed on an uprooted stump, after which they were brought to the laboratory where they were kept watered for a further two months before opening them up. In two of the five pots a white mycelium had developed superficially on the roots, and in one case the typical *F. lignosus* rot was seen. The identity of the fungus in these two pots, although hardly in doubt, was confirmed in culture. The roots in the other three pots had been invaded by saprophytic fungi.

There was no possibility that the *F. lignosus* had entered from the ground, for the soil had been dug away and the pots supported on bricks. It must be concluded that the infection originated from spores. In the laboratory, however, the results were negative. The inoculum was soil collected from beneath fructifications in the field, and passed through a 1 mm sieve to remove plant debris. There were two methods of test; in the first case the roots were buried as in the field experiment described above, in the other they were placed in Roux tubes and covered with the supposedly infected soil. Although neither method gave *F. lignosus* infections, it is of interest to record that mycelium and rhizomorphs of a species of *Poria*, tentatively identified as *P. hypobrunnea*, were found in one of the pots.

Attempts were made in the laboratory to inoculate seedlings growing in pots, and root sections buried in soil, with spores or

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insect fras obtained from freshly collected fructifications of *F. lignosus*. The stems of the seedlings were severed, with the intention of weakening resistance of the roots, but niether they nor the root sections became infected.

Probable case of natural infection by spores of F. lignosus — A few small fructifications of *F. lignosus* were noticed growing at the fork of an old rubber tree on the Experiment Station. They were not quite typical in appearance but the identity of the fungus was confirmed in culture. The tree had been attacked by termites, the fork being covered with their mudwork, and the trunk had been split by the wind at this point. A careful examination of the collar showed it to be healthy and not attacked by root parasites. As the fungus had no contact with the ground it would appear that this is a case in which spore infection by *F. lignosus* has occurred naturally.

Spore production by fructifications of F. lignosus — Opinions have differed in the past as to the spore production of *F. lignosus*. SHARPLES* has briefly discussed the different opinions—that only a few spores are ever produced, that spores are produced abundantly by young fructifications, or during certain times of the year.

With a view to obtaining more information, fructifications were collected during the latter half of the year from two estates in Selangor and brought into the laboratory for observation. Viable spores were produced in abundance in all six months from fructifications of all ages. Thus, one which was only one inch across produced abundant spores, and many were produced by a 14 in × 9 in fructification more than six months old and riddled by boring beetles.

For these observations the fructifications were kept in a damp chamber. Most of the spores were discharged during the night, spore production virtually ceasing a day after collection.

Viability of spores of F. lignosus after storage — In a field experiment which is projected an attempt will be made to infect rubber stumps by spraying them with suspensions of spores of *F. lignosus*. Since detached fructifications liberate spores abundantly in the laboratory only for the first twelve hours or so, the question of storage is important to the production of suspensions suitable for the experiment.

Spores from fresh fructifications were collected overnight on $\frac{3}{4}$ inch square cover slips, which were held under fine wire gauze to retain insect fras. A damp chamber could not be used because

*A. SHARPLES, *Diseases and Pests of the Rubber Tree* (1936) 122, 124

spores quickly germinated in the water which condensed on the cover slips. Spore production, however, was not noticeably less at ordinary laboratory humidities. Spores collected in this way were divided for storage at laboratory temperatures and in the refrigerator. To determine the viability of the spores after different storage times the slips were inverted on to corn meal agar in petri dishes. While the results obtained were rather variable, it may be generally stated that the germination rate fell off rapidly from the third to the fifth day in the laboratory, and from the second to the fourth day in the refrigerator.

I(2) STUDIES CONCERNED WITH THE IMMEDIATE PROBLEM OF ROOT DISEASE CONTROL

Rate of loss of infectivity by diseased root fragments — Since no reliable data are available as to how long a fragment of diseased root can persist as a source of infection when buried in the soil, an experiment has been laid down on the Experiment Station to provide the necessary information. The point at issue is one of considerable importance in connexion with the problem of eradicating root disease prior to replanting, particularly when this involves the use of mechanised methods.

For the purpose of these observations an area of about 1,000 sq ft was thoroughly dug over to a depth of two feet and all buried timber and roots removed. Within this area, which is enclosed with a barbed wire fence, sections of roots naturally infected with each of the three major root parasites have been buried to a depth of one foot, as material became available. The roots have been arranged in six groups according to diameter ($\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, 2 and 3 inch) and in two groups according to length (1 ft and 2 ft). The rate of loss of infectivity is to be assessed by removing pairs of roots representative of each size category and of each pathogen at intervals of two months, and determining by the usual cultural methods whether the fungus is still viable.

Field study of the economics of root disease control — Difficulties were experienced in putting down the experiments described in the last report*. It became necessary not only to re-site the experiment on Pataling Estate, but also to re-design it with plots reduced in size from two acres to one and a half. The area has been permanently marked with concrete posts, and a plan made to show the positions of all old stumps within nine feet of the hedges in which the young rubber is planted. Isolation trenches have since been dug.

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TABLE V: LABOUR EMPLOYED IN STUMPING, CLEARING AND CUTTING TIMBER

Field No. and stand	*Operation*	*Man days per acre*		*Trees per man day*	
		6 hour day	*8 hour day*	*6 hour day*	*8 hour day*
Field 7 *85 trees/acre*	*Stumping* *Clearing & Cutting*	13.7 64	10.3 48	6.2 1.3	8.3 1.8
	Combined	77.7	58.3	1.1	1.5
Field 9 *90 trees/acre*	*Stumping* *Clearing & Cutting*	11.5 57	8.6 43	7.8 1.6	10.5 2.1
	Combined	68.5	51.6	1.4	1.8
Field 11 *120 trees/acre*	*Stumping* *Clearing & Cutting*	24.4 64	18.3 48	4.9 1.9	6.6 2.5
	Combined	88.4	66.3	1.3	1.7

Notes: In Fields *7* and *9* laterals were cut as near to the trunk as was needed for easy felling. In Field *11*, four feet of the laterals on the near side of the tree, and at least six feet on the far side of the tree, were removed.

The experiment on Dusun Durian Estate has had to be abandoned, and no alternative site on a coastal estate has yet been found.

Evaluation of various methods of stump poisoning — The results of a trial carried out on Pataling Estate in 1948 were recorded in the last report. Sampling errors were high but, as samples from each of the five stumps in a treatment were bulked, no estimate of the error could be made. In a further trial which has been laid down on the Experiment Station it is hoped that sampling errors will be reduced by careful cleaning of the auger between the taking of the samples, and by having each sample estimated separately. Another point of difference from the earlier trial is that one treatment (the poison mixed with a paste made from tapioca flour and painted on to the cut surface of the stump) has been omitted, as it was then judged to be virtually useless.

Cost of stumping and clearing in preparation for replanting — Figures relating to the labour used in stumping and clearing an area were obtained in the course of preparation of three fields on the Experiment Station for replanting. A Trewhella winch was used for stumping, after which the area was cleared and the trees cut for firewood. It was not possible to cost the last two operations separately. Chinese labour was employed, and paid on the basis of firewood output; more man days per acre would probably have been required employing estate labour. The figures obtained are given in TABLE V, expressed both as man days per acre, and as trees per man day.

Tolerance to arsenic of the three major root parasites in culture — From preliminary observations* on their growth in culture on potato dextrose agar containing 625 parts per million arsenic in the form of As_2O_3 it was found that *F. lignosus* was the most tolerant, *G. pseudoferreum* intermediate, and *F. noxius* the least tolerant of the presence of the poison. The experiment has been repeated with a range of arsenic concentrations, to find within limits the minimum concentration necessary completely to inhibit the growth of each. For each fungus a range of six concentrations of arsenic was made up, selected on the basis of the earlier observations. Three slants were prepared for each concentration.

F. lignosus and *G. pseudoferreum* were greatly retarded even at the lowest concentrations tested (1250 and 625 p.p.m respectively), but some growth took place in two of the tubes. As the age of

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the cultures increased slight growth was seen in progressively higher concentrations of arsenic. The final results after 2 months were:

F. lignosus 2500-3000 p.p.m As_2O_3
G. pseudoferreum 1125-1250 p.p.m As_2O_3

where the higher figures have allowed no growth in any tube, while the lower figures have allowed at least slight growth in one tube. The range of concentrations taken for *F. noxius* was altogether too high, the lowest concentration (500 p.p.m) being completely inhibitory.

When these figures are compared with the arsenic concentrations found in roots of poisoned stumps† it is seen to be unlikely that stump poisoning would make the host tissue sufficiently toxic to *F. lignosus* or *G. pseudoferreum* to prevent their growth. The value of the method would seem to be as previously supposed—that the poison opens the way for saprophytic fungi which prevent the parasites becoming established. Whether any direct inhibition of *F. noxius* is possible remains to be seen; but it is in any event the least important of three root parasites.

I(3) INFLUENCE OF INTER-CROPS AND UNDERGROWTH ON THE INCIDENCE OF ROOT DISEASE

Work projected under this heading is in abeyance, pending the appointment of a Soil Microbiologist.

I(4) MINOR ROOT DISEASES

An underemined parasite — The pathogenicity of a basidiomycetous fungus that was isolated from a root during last year has now been established. In culture this organism closely resembles one isolated before the war, then tentatively assigned to the species *Poria hypobrunnea*—the cause of the red root disease of rubber in Ceylon. As the Malayan fungus has not been observed to form any fruit bodies its identification is a matter of some difficulty. Cultures have been forwarded through the Commonwealth Mycological Institute to the Forest Products Research Laboratory at Princes Risborough.

Sphaerostilbe repens B. & Br. — A pure culture of *S. repens* has been established from the conidial (*Stilbum*) stage of this fungus, which appeared as the result of a chance infection at the collar of a two weeks old potted rubber seedling that had been intentionally wounded in this region some days previously. The characteristic rhizomorphs, accompanied by numerous *Stilbum* fructifications, have been observed to develop on potato dextrose and glucose agars after about four days growth.

†*Rep. Rubb. Res. Inst. Malaya* (1945-8) 146

II

DISEASES OF THE TAPPING PANEL

II(1) MOULDY ROT (CERATOSTOMELLA FIMBRIATA)

From the monthly reports of the Smallholders' Advisory Service it appears that mouldy rot was a little less prevalent than in 1948. Even so, being recorded on about 10% of all holdings inspected during the year, it stands out as the most important disease with which the smallholder has to contend. Perak and Pahang were the states with the highest incidences; Malacca had the lowest. Seasonal fluctuations in incidence were in general not very strongly marked in the west coast states and Pahang, Selangor being an exception; but in Trengganu and Kelantan outbreaks were highly seasonal, a large proportion of holdings being affected during the wet monsoon.

In advisory work, stress continues to be laid on the need for regular and frequent application of fungicides, as it is clear that many reported failures to control the disease are due to inattention to this most important point.

The testing of fungicides *in vitro* and in the field has been continued from last year. One material has been found outstanding—Fixanol V.R.—which at the low concentration of 0.25% in water compares favourably with the best of the approved tar acid fungicides at a concentration of 5%.

Observations on Ceratostomella fimbriata in culture — A saprophytic strain of *C. fimbriata* growing on newly exposed surfaces of rubber wood on the Experiment Station was taken into culture and compared with the pathogenic strain which causes mouldy rot. The three media used—potato dextrose, corn meal, and oats agars —had little effect on the cultural characteristics. On all of them the saprophytic strain grew more rapidly, and otherwise differed from the pathogenic strain chiefly in that abundant perithecia were produced but no macroconidia. The two strains also differed biometrically; the saprophyte had broader hyphae, and narrower conidiophores, and there were other differences.

When cultured on sterile rubber wood the saprophytic strain grew profusely and produced perithecia. The pathogenic strain grew much more slowly, produced no perithecia, but abundant macroconidia and endospores.

A strain of *C. fimbriata* distinct from the pathogen of mouldy rot is known in America, where it causes a disease of sweet potatoes. The pathogenicity to sweet potatoes of the saprophytic strain

described above has been tested by inoculation; no infection occurred.

When BEELEY*studied the saprophytic *Ceratostomella* from rubber wood he concluded that it should be made a new species, and this view would seem to be justified.

II(2) BLACK STRIPE (PHYTOPHTHORA PALMIVORA)

Only one case of black stripe was brought to our notice during the year; it occurred on an estate in Perak near Sungei Siput, where the local climate is known to be particularly favourable to the disease.

II(3) EVALUATION OF FUNGICIDES

In vitro tests with borax — In view of a recent report† of the value of borax in controlling *Ceratostomella fimbriata* on sweet potato, it was tested *in vitro* against the pathogen of mouldy rot by a method already described‡. It was found to be incompletely fungicidal at a concentration of 4%.

Field trials with fungicides — Field trials conducted in the manner described in the last report§ were carried out with Phygon and T.M.T.D. (tetramethyl thiuramdisulphide) to follow up earlier results. The experiments included an untreated control plot, and a plot treated with one of the best approved tar acid fungicides to provide the standard of efficacy.

Phygon at a concentration of 0.5% obtained an efficacy rating of 3 after fourteen applications, against 100 after seven applications of the standard treatment. Earlier tests had shown its phytotoxic limit to be 1%. Its failure to control the disease satisfactorily at 0.5% therefore means that it is unsuitable for the treatment of mouldy rot.

In field trials carried out during 1948 it was found that 1% T.M.T.D. was insufficient to give satisfactory control of the disease, and although the phytotoxic limit had not been reached higher concentrations were considered to be ruled out by considerations of price. Subsequently, when it appeared that large scale manufacture would effect a price reduction, it was decided

*BEELEY, F. *J. Rubb. Res. Inst. Malaya* 1 (1929) 260

†MARTIN, W.J., LUTZ, J.M and RAMSEY, G.B. *Phytopathology* 39 (1949) 580

‡*Rep. Rubb. Res. Inst. Malaya* (1945-8) 119

§*Rep. Rubb. Res. Inst. Malaya* (1945-8) 153

to test T.M.T.D. at slightly higher strengths. At 1.5% and 2.0% the efficacy ratings obtained after 14 applications were 56 and 76 respectively, against 100 after nine applications of the standard treatment. On these figures it would seem that T.M.T.D. may be dismissed as a mouldy rot fungicide.

The successful results obtained last year with Fixanol V.R. at a concentration of 0.25% led us to carry out large scale trials with this material. Two samples were available, one coloured by the addition of 10% of a dye, the other sample uncoloured. They were compared at a concentration of 0.25% of the active ingredient, by spraying on alternate (non-tapping) days over 5 acres and 20 acres respectively. After nine applications both materials had completely controlled the disease, no trees showing any sign of mould. The interesting observation was made that re-infection was longer delayed on those trees treated with the coloured material; this effect is being investigated.

Included with the field trials of water miscible materials were four other treatments: octyl cresol dissolved in palm oil at concentrations of 2.5% and 5%; and Vacuum Product 2295-IA as a 50% solution in Diesoline and as a 45% solution with addition of 5% of Solignum. All four preparations, being too viscous to be sprayed, were brushed on to the trees.

Efficacy of the octyl cresol and palm oil solutions could not be assessed in the usual way, as the oil obscured the fungus. Instead, samples were taken from the surface of the tapping cut after seven applications and again after fourteen, to be kept in a damp chamber. *C. fimbriata* grew freely from all the samples, showing that the treatments were ineffective. Furthermore, subsequent inspection of the panels showed them to have been injured in the course of the trial.

The two mixtures containing V.P. 2295-IA dissolved in Diesoline were found to cause considerable bark burning, contrary to our experience in 1947. As the sample of the grease was the same, the burning is attributed to the Diesoline used in the recent tests.

Tests with a new proprietary tar acid fungicide — Tests with Ialine White Disinfectant, a tar acid emulsion submitted by the Prince Regent Tar Company Limited, have been completed and shown it to be suitable for the treatment of mouldy rot. In preliminary tests it was found to be non-toxic to bark at concentrations below 15%, although considerable injury resulted from application of a 20% emulsion. Under the conditions of an *in vitro* test it was fully fungicidal at 3%. In field trials the efficacy ratings after

fourteen applications were 53 and 92 for 3% and 5% concentrations, while a 10% concentration equalled the standard treatment in rating 100 after nine applications.

2(4) OTHER PANEL DISEASES

Pathogenicity of Fusarium to newly tapped bark — Three isolations of a species of *Fusarium* which is frequently found growing in association with *Ceratostomelea fimbriata* were tested during 1948 for their pathogenicity to newly tapped bark. Two cultures produced a conspicuous white bloom, but necrosis was only superficial. Dry weather, however, rendered the result inconclusive. The experiment has been repeated by inoculating panels of ten year old budded and seedling trees with the same two cultures. Rain which fell on the day of inoculation may have washed the inoculum off some of the trees, where no mould had developed on examination fourteen days later. During this period the weather continued wet, and so favourable for disease development; yet although with both cultures there were cases in which slight sinking and discolouration of the bark occurred, the inner cortex was found to be healthy. It is concluded that these strains are at most but feebly parasitic on newly tapped bark.

III

SECONDARY LEAF FALL

From an analysis of the monthly reports received from the Smallholders' Advisory Service it would appear that wintering started in most parts of the Peninsula during January, notable exceptions being the three east coast districts, Kota Bahru, Kuala Trengganu and Pekan, where it did not become generally evident until about a month later. On the whole its progress was rapid with the result that refoliation was advancing well in February and approaching completion by the end of March or early April, except on the east coast where it continued on into May. During this period outbreaks of secondary leaf fall are known to have occurred in every State and Settlement in the Federation other than Kelantan and Trengganu. In general the attack seems to have been slightly more intense than usual, some 15 per cent of the outbreaks brought to our notice being described as 'severe'.

TABLE VI: DISTRIBUTION OF KNOWN OUTBREAKS OF SECONDARY LEAF FALL

State or Settlement	*Number of outbreaks*
Kedah	32
Penang & P. Wellesley	10
Perak	34
Pahang	1
Selangor	32
Negri Sembilan	10
Malacca	20
Johore	13

The presence of the disease was confirmed on 152 estates and smallholdings. Distribution is shown in TABLE VI. Further outbreaks of moderate severity were recorded from two estates, one in Johore and one in Pahang, during September. Both were due to a combined attack of *Gloeosporium alborubrum* and the yellow tea mite *Hemitarsonemus latus;* some *Oidium heveae* was present, and also thrips (*Scirtothrips dorsalis*) in the latter case only.

III(1) STUDIES ON THE ASSOCIATED PARASITES

Observations on the incidence of the parasites — Examination of 320 representative specimens forwarded for confirmatory diagnosis yielded information regarding the four parasites as presented in TABLE VII which brings out markedly the major importance of *Oidium heveae* as a factor in secondary leaf fall. It was this fungus, moreover, that was the dominant parasite in 15 out of the 25 outbreaks that were described as severe—eight of which, incidentally, involved clone Tj. 1.

TABLE VII: INCIDENCE OF THE PARASITES ASSOCIATED WITH 320 CASES OF SECONDARY LEAF FALL

Parasite	*Percentage of cases in which*		
	Present	*Dominant*	*Unassoc**
Oidium heveae	95	63	41
Hemitarsonemus latus	35	7	0.6
Gloeosporium alborubrum	31	10	3
Scirtothrips dorsalis	15	Nil	Nil

* *i e unassociated with any of the other three parasites*

In the majority of cases where *Scirtothrips dorsalis* occurred it was found to be present only in small numbers. However, in view of the extreme agility of this insect, it is a matter for question whether the field population was really as low as these observations suggest.

It is of interest to compare the figures given in TABLE VII with similar data obtained in 1948 for the three major parasites. This is done in TABLE VIII. The impression derived from this comparison is that conditions during the 1949 refoliation season favoured the reproduction of *Oidium heveae* but were inimicable to that of *Hemitarsonemus latus*.

TABLE VIII: PERCENTAGE INCIDENCE OF THE THREE MAJOR PARASITES DURING THE REFOLIATION SEASON (JANUARY-JUNE) OF 1948 AND 1949

Parasite	*Present*		*Unassociated*	
	1948	*1949*	*1948*	*1949*
Oidium heveae	89	95	24	41
Hemitarsonemus latus	68	35	5	0.6
Gloeosporium alborubrum	27	31	2	3

The question of the perennial activity of Oidium heveae — Observations carried out during 1948 produced evidence which suggested that *Oidium heveae* was in no way dependent on a resting stage for its perpetuation since it is quite capable of maintaining a continuously active existence, the intervals between the annual refoliations of its host (when its development reaches a climax) being passed in an inconspicuous manner on the leaves of self sown seedlings and on the occasional new flush produced by mature trees.

With the object of obtaining further information on this point a monthly inspection of smallholdings in Selangor was carried on through the year; only the July inspection was omitted, owing to unforseen circumstances. During the first four months of the year *Oidium* was prevalent on refoliating trees throughout the State. The monthly inspections also revealed it in an actively sporulating condition on developing leaves of mature trees from August to the end of the year, and on flowers from August to November. The only records during May and June were from leaves of self sown seedlings; actively sporulating colonies continued to be found in this situation to the end of the year except during July, when no inspection was made, and October.

In spite of the lack of data for July these observations lend strong support to the contention that *Oidium heveae* is perennially active, and that in consequence there is no need to postulate a dormant stage to account for its survival.

III(2) STUDIES ON VARIATIONS IN CLONAL RESISTANCE

Comparative observations on four clones — In an attempt to determine whether Pil. B. 84, B.D. 5, Tj. 1 and AVROS 50 exhibit any significant differences in resistance to the attacks of the three major parasites associated with secondary leaf fall, a weekly record was kept of the number and condition of the leaves falling on unit areas from trees of these clones on the Experiment Station. It became apparent that it would not be possible to judge relative susceptibility merely by comparing the number of young diseased leaves falling from each clone over a given period, but that it would be necessary to determine what proportion the diseased leaves bore to the total number produced. The observations were in consequence discontinued, to be resumed during the next wintering season with records of the number of wintered leaves falling per unit area (which should be representative of the total number carried by the trees), and the number of immature leaves falling during refoliation as the result of infection.

Effect of sulphur dusting on defoliation of clone B.D. 5 — The observations on the effect of sulphur dusting on chronic defoliation of B.D. 5* have been concluded. After 49 approximately weekly applications made at the heavy rate of 40 lb per acre no significant improvement in the condition of the foliage became apparent.

Subsequent observations in the laboratory have an important bearing on this result. It has been found that sulphur dusted on to the surface of the medium (potato dextrose agar) has little effect on growth in culture of *G. alborubrum* isolated from fallen B.D. 5 leaves. Furthermore, in drops of a spore suspension placed on glass slides dusted with sulphur, over 50% of the spores germinated and produced appressoria, even though the deposit was far heavier than would be expected on the leaf of a sulphur dusted tree. This tolerance of *G. alborubrum* to sulphur makes it impossible to deduce from the field results what part the fungus plays in B.D. 5 defoliation, but it may be taken as certain that mites (*H. latus*) are unimportant as they are known to be controlled by sulphur.

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IV

LEAF DISEASES OF YOUNG PLANTS

(1) BIRD'S EYE SPOT (HELMINTHOSPORIUM HEVEAE)

This disease of nursery plants has continued to receive close study in the laboratory and in the field. While a considerable amount of information has been accumulated, a satisfactory procedure for its control has yet to be found. Much of the following report is in summarised form, as a full account of the work is in course of preparation by the Pathologist.*

Mycological Studies

Viability of the conidia — The germination tests started last year have shown conidia to be capable of germinating after six months storage under air dry conditions; but after nine months only a few showed incipient germination.

Other spore forms — The study of pycnidial and perithecial fungi which develop on old *Helminthosporium* lesions has been continued. The former have been found to include one or more species of *Phyllosticta* and a fungus with triseptate scolecospres; and the latter a species of *Mycosphaerella* and one of *Ophiobolus,* both of which genera are known to have *Helminthosporium* as the imperfect form in some of their species. So far no kinship has been shown to exist between *H. heveae* and any of these forms. Experimental inoculations carried out with the *Mycosphaerella* indicate that it is unable to infect *Hevea* seedlings.

Germination of the conidia — Observations have been made on freshly formed conidia obtained from heavily sporing lesions. The rapid growth of these spores has been recorded by a set of photomicrographs which show incipient germination to occur within the first hour, a germ tube as long as the spore within four hours, and appressorium formation within eight hours.

Effect of hydrogen ion concentration — Conidia were found to germinate in a damp chamber in drops of culture solution adjusted to a wide range of hydrogen ion concentrations (pH 3.0 to 11.5). Within the range pH 5.0 to 7.5 no conidia failed to germinate. Optimum development of the hyphae occurred at pH 6.0 Cultures developed normally on Dox agar between pH 4.2 and 7.9. Sporing was exceptionally heavy on all the acid media.

Influence of temperature on growth in culture — Temperatures above 40°C strongly inhibit growth in culture. Even below

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this figure it has been found that there is a marked inhibitory effect which persists after the culture has been returned to normal conditions.

Pathological Studies

Dissemination of the disease — The small numbers of spores of *Helminthosporium heveae* caught in a trap, even in a heavily infected nursery, led to a re-examination of the supposition that they are windborne. It has been observed that dry spores are not readily shaken or blown from the leaf spots. This rather suggests insect transmition but there is also the possibility that spores are loosened by rain and dispersed in rain drops.

It is possible to obtain leaf flushes quite free of the disease, even on plants growing in a heavily attacked nursery, by suitably enclosing them. Various types of screen and cage have been produced in an attempt to elucidate the problem of the normal method of spore dissemination.

Conditions favouring infection — Half an acre of seven foot high atap shade was erected during February in the Smallholders' nursery on the Experiment Station. It has provided the clearest evidence that seedlings grown under shade are far less susceptible to infection by *H. heveae* than are those grown in the open. With the execption of a few boundary rows the shaded plants developed a striking expanse of healthy dark green foliage, while the surrounding plants became heavily infected and severely defoliated. Until the end of June, when the atap began to thin out, there were so few lesions on the shaded leaves that a close examination was needed to detect them. The contrast between the sun and shade leaves was strikingly shown when the terminal shoots penetrated the atap; those leaves which developed above the shade were heavily attacked.

It is of interest to record that the shaded plants at one stage during their growth suffered from quite sharp attacks of *Oidium heveae* and mites (*Hemitarsonemus latus*). Both these outbreaks were transitory, that due to the mites being brought under control by predators.

It should also be noted that measurements showed the shade to have retarded growth slightly, despite its beneficial effect on the condition and the quantity of the foliage.

Although the shade plants have at times been wetted by rain dripping through the atap, daily observations have shown that dew was never formed on their leaves even when plants in the open were laden with it. It is supposed that the shade exerted this effect by reducing the rate of radiant heat loss from the leaves.

As possible explanations of the effect of shade in keeping seedlings virtually free of the disease, the following hypotheses may be advanced:

(*a*) suppression of dew formation making conditions unfavourable for spore germination;

(*b*) production of a shade type of leaf conferring resistance;

(*c*) light being necessary for development of the fungus.

In order to distinguish among these it is clearly desirable to separate the effect of the atap on light intensity from its effect on dew formation. To this end a structure was erected providing shade by means of movable blinds. By raising them at sunrise and lowering them at sunset it was possible to prevent dew formation on the underlying seedlings without depriving them of any considerable amount of light.

That light has a direct effect on the fungus has been shown by artificial inoculation experiments carried out on potted seedlings under light conditions ranging from full sunlight to total darkness. Progressively with the reduced light intensities the resulting lesions became smaller, fewer in number, and sporing was reduced to nothing.

Mode of infection — A satisfactory technique of inoculation has been developed depending on the use of air dried spores, and with its aid observations have been made on the mechanism of infection. Germination of the spore may take place within two hours of its alighting on the surface of the leaf, and penetration of the host tissue (accompanied by a slight swelling of the tip of the germ tube) has been observed to begin about four hours later. A definite appressorium develops within twenty hours of the initiation of infection and by this time a dark coloured lesion surrounded by a pale yellow halo is already visible.

Tests were carried out on potted seedlings to determine the minimum period for which moist conditions must obtain in order for infection to occur. Twelve seedlings inoculated between 0800 and 0900 hours were covered with bell jars which were successively removed at hourly intervals. No infection was secured after less than nine hours covering, but it is likely that this figure would have been shorter if the air under the bell jars had rapidly been brought to saturation.

Artificially inoculated seedlings in pots never gave rise to typical large bird's eye spots. An opportunity to study the effect of using the same technique in the field was provided by a small nursery in which a high proportion of the seedlings were unattacked by the disease. It has been found that the largest and most typical

lesions develop on leaflets inoculated at the stage when they are fully grown but still hanging limply. Previously it had been assumed that large lesions develop from small ones by centrifugal growth. It now appears that they arise when the leaf is attacked at a particular stage in its development, by rapid growth from the point of penetration: in two days the boundary of the future spot is delimited; in another two days the enclosed leaf tissue is dead; by the sixth day the white centre of the spot is apparent, to be followed later by conidiophore and spore production. The rampant infection of very young leaves is thought to result from the simultaneous attack of a number of spores; it does not appear to be the result of unusual weather conditions.

Source of infection — LA RUE'S finding* that *H. heveae* can infect the leaves of mature trees has been confirmed; but, since only two such cases have been observed out of more than 300 specimens of leaf disease examined in connection with the annual survey of secondary leaf fall, it is difficult to accept his conclusion that lesions present on the leaves of mature trees provide the usual source of infection for newly established nurseries.

The suggestion is that *H. heveae* may have alternate hosts among the more common weeds, and certain grasses are particularly suspect. It is relevant here to record that a disease attacking oil palm fronds on a coastal estate was found to be associated with a species of *Helminthosporium,* the spores of which were similar in size to those of *H. heveae.* A rubber seedling growing in a pot developed lesions after inoculation with these spores, but they were small and atypical.

Susceptibility of hybrid seedlings — There has been no indication that they have any natural resistance to bird's eye spot disease. In a nursery on the Experiment Station *Hevea spruceana brasiliensis* hybrid seedlings have been interplanted with *H. brasiliensis* over a small area.

Development of Improved Methods of Control.

Effect of fungicides on the germination of spores of Helminthosporium heveae — A range of synthetic materials was tested by a slide germination technique using conidia of *H. heveae.* For comparison the standard laboratory Bordeaux mixture specified by the American Phytopathological Society† was included. The tests were made over the concentration range 0.00001% to 0.001% of the commercial materials, and from the observed percentage germination the L.D. 50 values given in TABLE IX have been estimated.

*LA RUE, C.D. *Phytopathology* 12 (1922) 60

†*Phytopathology* 33 (1943) 633

They are seen to be fairly closely comparable. It should be noted that the figure for Bordeaux mixture, which is considerably lower, is expressed in terms of the copper content.

TABLE IX: EFFECT OF FUNGICIDES ON SPORE GERMINATION OF H. HEVEAE L.D. 50 VALUES EXPRESSED AS PERCENTAGES

Fungicide	*Composition*	*L.D. 50* (%)
Bordeaux mixture	*(Standard)*	0.00005 *(Cu)*
Fermate	80% *ferric dimethyldithiocarbamate*	0.00055
Zerlate	80% *zinc —do—*	0.001
Tersan	50% *tetramethylthiuram disulphide*	0.0005
Fixanol V.R.	100% *tetradecylpyridinium bromide*	0.0006

Two other materials—Dithane Z-78 (70% zinc ethylene bis-dithiocarbamate) and Shirlan (50% salicylanilide)—did not prevent germination at the highest concentration tested (0.001%).

Field trial of fungicides and sticking agents — Following the field experiments carried out in 1947 and 1948 a further trial designed to assess the value of a number of fungicides and sticking agents as prophylactics against bird's eye spot was completed. The experiment was laid down in part of the Smallholders' nursery on the Experiment Station as three blocks of twelve plots of one twentieth of an area each, among which the treatments were randomised.

The following materials were tested:

Perenox (50% Cu as Cu_2O) at 4 lb per 100 gallons, alone and with addition of five sticking agents

M & B Bordeaux mixture at the strength recommended by the makers, approximately equivalent to a 4:5:40 mixture

Spersul (a wettable sulphur) at 5 lb per 100 gallons

Phygon (dichloronaphthoquinone) at 1 lb per 100 gallons

Perelan (17% Cu as Cu_2O) a dust

S.S. Sulphur a proprietary dusting sulphur

The sprays were applied with a Hymatic portable compressor fitted with an S.L. 3 lance, at a pressure of 75-80 p.s.i When this outfit was out of action owing to engine trouble the applications were made with a Four Oaks lance at a pressure of about 60 p.s.i. The rate of application was 60 gallons per acre for Perenox, Spersul and Phygon, and 50 gallons per acre for the Bordeaux Mixture.

TABLE X: FIELD TRIAL OF FUNGICIDES AND STICKING AGENTS

Mean increase in height in inches of 100 plants over a period of three months

Treatments	*Blocks*			*Totals*	*Overall Means*
	A	*B*	*C*		
SPRAYS					
Perenox (4:100)	13.7	9.7	15.0	38.4	12.8
„ + 0.05% *Albolineum*	14.2	11.4	16.5	42.1	14.0
„ + 0.05% *casein*	15.1	14.6	13.6	43.3	14.4
„ + 0.2% *ammoniated latex*	13.7	10.5	12.2	36.4	12.1
„ + 0.2% *acid serum*	17.1	16.2	17.1	50.4	16.8
„ + 0.2% *Goodrite p.e.p.s.*	10.4	13.7	13.2	37.3	12.4
M & B Bordeaux Mixture (4:5:40)	15.3	13.8	13.0	42.1	14.0
Spersul (5:100)	10.4	9.7	12.5	32.6	10.9
Phygon (1:100)	15.8	12.9	12.8	41.5	13.8
DUSTS					
Perelan	14.6	15.6	14.9	45.1	15.0
S.S. Sulphur	9.3	12.3	14.0	35.6	11.9
CONTROL *(no treatment)*	13.7	12.4	12.9	39.0	13.0

Standard error of a difference between two treatment means = 1.32
5% significant difference between two treatment means = 2.73

TABLE XI: FIELD TRIAL OF FUNGICIDES AND STICKING AGENTS

Mean girths in millimetres of 25 plants at 6 inches above soil level

Treatments	*Blocks*			*Totals*	*Overall Means*
	A	*B*	*C*		
SPRAYS					
Perenox (4:100)	6.2	4.3	4.2	14.7	4.90
„ + 0.05% *Albolineum*	6.6	5.8	3.6	16.0	5.33
„ + 0.05% *casein*	6.5	6.5	3.9	16.9	5.63
„ + 0.2% *ammoniated latex*	7.4	5.6	3.4	16.4	5.47
„ + 0.2% *acid serum*	9.2	5.6	4.8	19.6	6.53
„ + 0.2% *Goodrite p.e.p.s.*	5.9	5.3	4.6	15.8	5.27
M & B Bordeaux Mixture (4:5:40)	6.9	4.8	3.7	15.4	5.13
Spersul (5:100)	5.4	4.8	3.2	13.4	4.47
Phygon (1:100)	6.8	5.3	3.9	16.0	5.33
DUSTS					
Perelan	6.5	6.5	3.8	16.8	5.60
S.S. Sulphur	5.1	6.4	4.2	15.7	5.23
CONTROL *(no treatment)*	5.1	5.8	4.4	15.3	5.10

Standard error of a difference between two treatment means = 0.52
5% significant difference between two treatment means = 1.07

Dusts were applied with hand operated rotary dusters at the rate of 20 lb per acre.

Because of difficulties occasioned by abnormally dry weather in the latter part of 1948 the first round of treatment was not carried out until the beginning of February, by which time the plants were about 20 inches high. Fifteen applications were made, at weekly intervals, the total rainfall on the experimental area during the fourteen weeks being 25 inches.

Results were assessed by comparing height increases and girths, the former derived from measurement of 100 plants situated in the centre of each plot, and the latter based on measurements of 25 of these plants at the conclusion of the experiment. The data obtained are summarised in TABLES X and XI, inspection of which shows that only the one treatment Perenox plus acid serum resulted in an increase in growth over the untreated plots that was statistically significant. Even this treatment fell far short of providing a satisfactory control of the disease. The poorest results were obtained with the two sulphur fungicides, and there is a strong indication that treatment with Spersul actually led to a retardation of growth. It is interesting to note that the Bordeaux Mixture appears to have had no deletrious effect on the development of the plants despite its rather high lime content.

This very thorough trial of well proved fungicides and stickers has made it quite clear that the control of bird's eye spot presents a difficult problem. A further trial, on which a start had been made by the end of the year, will be described in the next report.

IV(2) GLOEOSPORIUM LEAF SPOT

Regular inspection of the Smallholders' nursery at Sungei Buloh has shown that in the very few cases where leaf infection was caused by some fungus other than the *Helminthosporium* it was almost invariably *Gloeosporium alborubrum* that was responsible.

Cultures of Gloeosporium — Repeated subculturing over two years of cultures Nos. 42 and 84 resulted in white non-sporing mycelial growths indistinguishable from each other. When inoculated into a potato plug both cultures spored freely, and showed their former distinct cultural characters when returned to an agar medium. An isolate made at this time of a *Gloeosporium* causing severe spotting of young leaves of nursery buddings was found to be the same as culture No. 42.

IV(3) OTHER LEAF DISEASES OF YOUNG PLANTS

Anthracnose — Reference was made in the previous report to an experimental inoculation with *Colletotrichum ficus* (No. 126) which resulted in the production of small atypical lesions. No increase in the size of these lesions, the largest of which was only 1 mm in diameter, has been observed to take place over a period of four months; but the pathogen was successfully re-isolated from one of the spots two months after the inoculation. This experience indicates that failure to reproduce normal symptoms of a disease when inoculated into laboratory plants is not a peculiarity of *Helminthosporium heveae* alone (page 25).

Colletotrichum sp. near C. gossypii Southworth—A species of *Colletotrichum* resembling *C. gossypii* (the cause of anthracnose of cotton) in that it gives rise to long, tapering, olive brown, septate setae bearing hyaline, ovate, basally pointed spores, has been observed more than once in association with irregular brown lesions occurring on mature leaves, particularly those of young plants.

Spores derived from a culture of this fungus (No. 182) isolated from the leaf of an eight year old tree of clone Pil. B. 84 were transferred directly to the leaves of young potted seedlings. Numerous small brown lesions eventually developed.

Guignardia rim blight — On two occasions perithecia have been found associated with a *Colletotrichum*. The perithecia are black, scattered, and immersed, of diameter 90-160mu. Asci are clavate, 52mu × 9.5mu; spores hyaline, oval, with obtuse ends, 12-14mu × 4.5mu. This would appear to be *Guigardia heveae* Petch, of which there is no record in Malaya since 1921, when Petch mentioned it as occurring in Singapore.

V

DEFENCE AGAINST SOUTH AMERICAN LEAF BLIGHT

Last year* attention was called to the threat constituted by South American leaf blight (*Dothidella ulei*) to the rubber growing areas of South East Asia. Measures designed to exclude it were described, stress being laid on the need for cooperation between all rubber growing countries in the region. As a result of representations

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made, the Commissioner General convened an international Technical Committee on Plant Protection to go into the matter and make recommendations.

The committee was composed of delegates representing the Governments of India, Indochina, Indonesia, Malaya and Singapore, and attended by observers representing the F.A.O. of the United Nations and the Government of the United States. It met on 22 and 23 February. The Head of the Pathological Division was present as a member of the Malayan Delegation. Complete agreement was reached on the necessity for cooperative action to protect rubber in South East Asia from South American leaf blight. The committee considered and unanimously agreed the draft regulations which had been drawn up by the Department of Agriculture in consultation with the R.R.I. with the object of excluding the disease by imposing stringent control on all traffic in plants emanating from tropical America.

Following consideration of a suggestion put forward by the Government of the United Kingdom, the committee also recommended that an international Phyto-Sanitary Conference should be convened to survey the whole question of plant protection in South East Asia. The conference was held in the Commissioner General's Office, Singapore, on 26—28 April. It was attended by delegates and observers representing thirteen countries in, or having interests in, South East Asia, and by representatives of the F.A.O. of the United Nations and the South Pacific Commission. The Head of the Pathological Division attended as a member of the Malayan delegation, and the Entomologist as an observer on behalf of the Rubber Research Institute.

The conference recommended *inter alia* the conclusion of a Phyto-Sanitary Convention for the South East Asia and Pacific Region, with a Permanent Advisory Commission to give effect to its decisions.

V(1) METHODS OF ERADICATION

Although no work on eradicant measures was carried out during the year, preparations were made for the investigations of flame guns and herbicides to be started early in the new year.

V(2) PROCEDURES DESIGNED TO ENSURE THE FREEDOM FROM DISEASE OF IMPORTED PLATING MATERIAL

The investigation of materials which might prove superior to sulphur for the disinfection of planting material has been continued

from last year, with some preliminary observations on seed dressings and a comprehensive field trial of budwood treatments.

Disinfection of seed — In studying the effect of disinfection with various fungicides on the subsequent germination of packed seed, treatments were applied to lots of 100 seeds each, the seeds then packed in moist charcoal and stored for 10 days before being planted out. The number that had germinated within a period of 40 days was used as the basis for comparison, the results for two trials being given in TABLE XII. Although both series of observations have been largely vitiated by the poor germination of the controls, the results obtained are recorded because they bring out the interesting fact that some of the fungicides have had the effect of markedly increasing the germination rate.

TABLE XII: TRIAL OF SEED DISINFECTANTS

Treatments	*Percentage germination*	
	Trial 1	*Trial 2*
Control (no treatment)	8	4
Spergon	7	3
Copper carbonate	7	20
Agrosan	12	34
Zerlate	15	11

Disinfection of budwood — The effect of prior disinfection with five fungicides on the viability of the packed budwood of ten R.R.I clones has been determined by a field trial carried out in collaboration with the Botanical Division. Twelve yards of budwood from each clone were employed in this test, two yards being dusted with each of the five fungicides and two yards being retained untreated as a control. The cut ends of one half of this yardage were sealed with Entwax, and of the other half with a grease (Vacuum Product 2295-IA). After treatment the budwood was wrapped in moist sterilised coconut fibre and packed in wooden boxes, a separate box being used for each fungicidal treatment. It was then stored for 12 days, except the control budwood and that treated with Fermate, which were stored for 13 days, since it proved impossible to complete all the budding in one day

TABLE XIII: EFFECT OF FUNGICIDAL TREATMENTS AND OF METHODS OF SEALING ON THE CONDITION OF BUDWOOD

Percentage of strippable buds

R.R.I. Clones	*Sulphur*			*Zerlate*			*Fermate*			*T.M.T.D.*			*Agrosan*			*Control*		
	G	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*
500	93	93	*93*	89	91	*90*	81	92	*86*	61	70	*65*	68	85	*76*	77	68	*72*
501	89	93	*91*	59	85	*72*	43	84	*63*	58	87	*72*	87	69	*78*	81	77	*79*
502	94	83	*88*	47	82	*64*	86	65	*75*	73	85	*79*	58	64	*61*	52	83	*67*
506	25	47	*36*	18	31	*24*	56	71	*63*	44	33	*38*	46	80	*63*	71	59	*65*
509	79	75	*77*	36	47	*41*	60	78	*69*	71	64	*67*	55	85	*70*	62	87	*74*
511	36	61	*48*	53	25	*39*	75	86	*80*	41	55	*48*	85	56	*70*	69	70	*69*
513	69	100	*84*	38	48	*43*	52	65	*58*	81	33	*57*	43	62	*52*	95	55	*75*
515	25	42	*33*	41	32	*36*	49	47	*48*	28	21	*24*	54	56	*55*	58	69	*63*
518	36	59	*47*	37	31	*34*	50	56	*53*	32	42	*37*	64	33	*48*	86	74	*80*
520	62	50	*56*	35	72	*53*	61	56	*58*	37	36	*36*	68	77	*72*	55	86	*70*
Means	61	70		45	54		61	70		53	53		63	67		71	73	

G = grease *W = wax* *M = mean*

TABLE XIV: EFFECT OF FUNGICIDAL TREATMENTS AND OF METHODS OF SEALING ON THE VIABILITY OF BUDS

*Percentage of successful buddings**

R.R.I. Clones	*Sulphur*			*Zerlate*			*Fermate*			*T.M.T.D.*			*Agrosan*			*Control*		
	G	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*	*G*	*W*	*M*
500	80	80	*80*	40	70	*55*	20	30	*25*	70	40	*55*	0	0	*0*	10	10	*10*
501	80	100	*90*	90	90	*90*	10	60	*35*	50	50	*50*	50	30	*40*	30	20	*25*
502	0	20	*10*	40	20	*30*	0	10	*5*	0	0	*0*	0	0	*0*	0	0	*0*
506	0	50	*25*	30	40	*35*	10	20	*15*	30	40	*35*	10	10	*10*	20	60	*40*
509	50	70	*60*	20	80	*50*	0	50	*25*	10	10	*10*	20	0	*10*	0	0	*0*
511	40	50	*45*	50	20	*35*	20	60	*40*	0	10	*5*	10	10	*10*	0	30	*15*
513	10	70	*40*	60	70	*65*	0	0	*0*	20	20	*20*	20	20	*20*	50	40	*45*
515	60	20	*40*	60	40	*50*	0	10	*5*	10	10	*10*	20	0	*10*	60	20	*40*
518	50	60	*55*	60	20	*40*	30	20	*25*	20	30	*25*	10	20	*15*	40	60	*50*
520	10	60	*35*	40	30	*35*	10	30	*20*	40	50	*45*	0	0	*0*	30	50	*40*
Means	38	58		49	48		10	29		25	26		14	9		24	29	

G = grease *W = wax* *M = mean*

**Based on a figure of ten buddings per clone per treatment (i e on a total 120 buddings per clone) irrespective of whether the quota of ten suitable buds was actually secured.*

owing to rain. At the end of this period the budwood was unpacked, washed, and carefully inspected before being passed to the budders. The only signs of damage to be observed occurred on some of the material that had been treated with Agrosan (an organomercurial).

Although the aim was to bud only ten buds from each yard of budwood, every bud that could be cut was removed and an attempt made to strip it. In this way a figure was obtained of the percentage of strippable buds, and, since it had already been found* that the 'strippability' of the buds may be adversely affected by certain fungicides (*e g* copper compounds), this figure can be regarded as providing some indication of the effect of the various treatments on the condition of the *budwood*. On the other hand the effect of these treatments on the viability of the *buds* was assessed by comparing the number of budgrafts that had become successfully established a month after budding. These two lots of data are summarised in TABLES XIII and XIV, which show that the results on the whole favour the use of Entwax rather than V.P. 2295-IA grease.

None of the fungicidal treatments appears to have had any markedly adverse effect on the 'strippability' of the buds; and although on this score Zerlate and T.M.T.D. (50% tetramethyl thiuramdisulphide) do not show up too well, it will nevertheless be observed that no treatment has been without a beneficial effect on at least one clone.

With regard to the more important aspect of this trial, namely the effect of the fungicides on the *viability* of the buds, reference to TABLE XIV will show that treatment with Zerlate actually increased the number of successful buddings made from seven of the clones, while treatment with sulphur was definitely beneficial with six of them. Taking the figures for waxed budwood separately, the results with sulphur are generally better than those given by Zerlate. Agrosan can clearly be dismissed as toxic. That it should be so is rather surprising in view of its negligible effect on 'strippability'.

On the queston of the reaction of individual clones the only point that calls for special mention is the evidence of extreme sensitivity to storage displayed by clone 502 under all conditions.

The outcome of this trial and of the former one is to confirm our earlier recommendation that, for general purposes, dusting sulphur should be used for the disinfection of consignments of budwood. It also enables us to make the further recommendation

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that budwood intended for despatch should have its cut ends sealed with Entwax rather than grease, and should be packed in sterilised coconut fibre rather than sacking.

We do not advocate the use of charcoal for the packing of budwood primarily because its presence adds greatly to the difficulties of inspection; in our view it would be desirable on this account alone to prohibit its use in the case of budwood intended for introduction into this country.

VI

STEM AND BRANCH DISEASES

(1) PINK DISEASE

Only three inquiries were received from estates; two were concerned with the disease in multiplication nurseries, the third related to a nearly mature area. The returns received from the Smallholders' Advisory Service indicated a slightly lower incidence than last year, with under 1% of the smallholdings visited reported as attacked. The states with the highest figures were Perak and Pahang (as for mouldy rot, for which the optimum conditions are similar) with over 2% and 3% respectively.

VI(2) PATCH CANKER

No report of patch canker has been received during the year.

VI(3) DISEASES OF YOUNG SHOOTS

Isolated cases have been encountered of *Phytophthora* and *Gloeosporium* die back of young buddings in the field and in the nursery.

VI(4) OTHER STEM AND BRANCH DISEASES

An unusual branch die back — An examination was made of an unusual form of die back which occurred on a coastal estate in Selangor. It was confined to clone 72 E, about nine years old, and involved only the central vertical branches, side branches being normal and bearing healthy foliage. The extent of the injury varied from several inches of an apical shoot to several feet of a well grown stem. It was conspicuous that the damage occurred where trees were exposed to the wind—on the margin of a closely planted field, and in another where the stand had been greatly reduced during the war.

Evidence that the clone is susceptible to wind damage was seen in broken branches and bark split at branch forks. The conclusion was reached that the die back was due to infection by a wound parasite following mechanical injury caused by movement in the wind—this explaining why the trouble occurred in exposed situations. Isolations made from diseased wood revealed, apart from the ubiquitous *Botryodiplodia theobromae,* a fungus which has since (1950) been identified as *Trametes incana**.

VII

INJURIES OF NON PARASITIC ORIGIN

Cases of sunscorch of seedlings, fire and lightning damage, and accidental poisoning with sodium arsenite have been brought to our notice during the year, the last more commonly than might be expected. Certain incidental observations which are of interest are recorded below.

Lightning injury — A species of *Pythium* close to *P. ultimum* has been isolated from the decaying bark of a root of a twenty year old seedling tree whose stem exhibited symptoms typical of lightning damage.

Sodium arsenite injury — Analyses carried out by the Soils Division have shown that as much as 250 p.p.m. of As_2O_3 may be present in the bark of trees that have been accidently injured by an intake of sodium arsenite. The presence of arsenic in stem or root specimens affected by this form of injury can often be detected by the garlic like odour that is given off by them, this becoming particularly noticeable if the specimens are moistened and held overnight in a closed container. On the assumption that the odour was due to the microbiological production of trimethylarsine it was thought that it might be possible to secure a qualitative test for the arsenic by bubbling air that had been drawn over the specimen through Biginelli's solution (10% $HgCl_2$ in 20% HCl), but on no occasion could any perceptible precipitate be obtained, even when the bubbling was continued for 10 days.

Sunscorch of seedlings — *Pestalotia palmarum* and a species of *Cercospora* are to be recorded as additions to the list† of fungi which occur on leaves injured by sunscorch.

**We are indebted to the Forest Products Research Laboratory, Princes Risborough, for this identification.*

†*Rep. Rubb. Res. Inst Malaya* (1945-8) 177

Burrs on tapping panels — An interesting case was reported of burr formation above the tapping cut of trees of clone B.D. 5 which had lost practically all their foliage. Careful examination of 18 burrs on three panels revealed that in 13 cases the burr had arisen on the site of a dormant bud (*Figure 1*), and although the other five appeared to have arisen in a different way from a deep seated lesion it was suspected that these actually represented buds which had atrophied. It is supposed that the dormant buds had been sensitised by the chronic defoliation, and that tapping had stimulated them into the abnormal activity which resulted in burr formation.

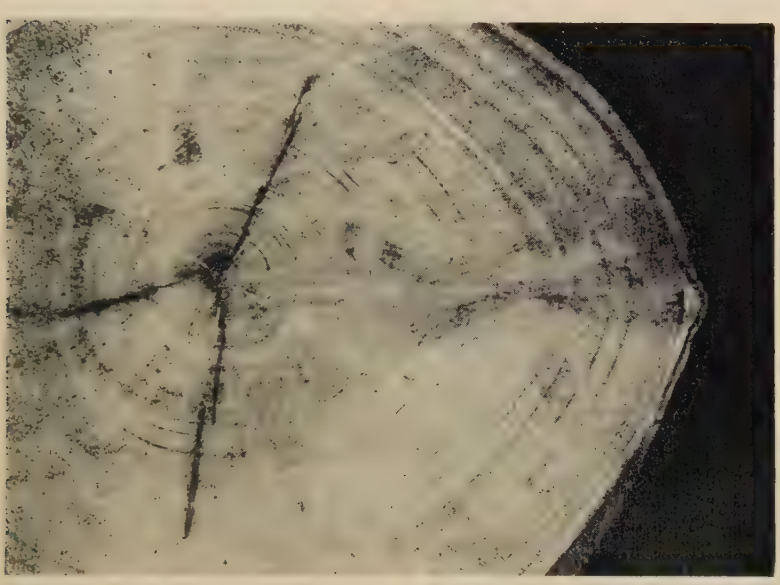

Figure 1. Transverse section of a B.D. 5 stem showing a burr formed on the tapping panel at the site of a dormant bud. The bud trace can clearly be seen.

VIII

TERMITES

An estimate of the extent of termite attacks on smallholdings is available from reports submitted by Rubber Instructors of the Smallholders' Advisory Service. During 1949 on only 1½% of 48,000 holdings visited were termite attacks reported; the number

of attacked trees would further be only a small fraction of those planted. It thus appears that termites are inconsiderable as pests of smallholding rubber. Although no comparable records are available it is likely that the incidence of termites on estates is higher, because more of them were planted from jungle.

Routine methods of control have been under test on the Experiment Station. Cost figures show that the standard method employing mercuric chloride is so inexpensive on a per acre per annum basis that it is difficult to imagine any eradicant measure, however successful, which could compete with it in price, even allowing for the need for long continued treatment. It is possible that the position would be different in a heavily attacked area.

A survey has been made of trees attacked by termites on part of the Experiment Station, with a view to investigating the possibilities and economics of carrying out intensive treatments which might eradicate the pest.

VIII(1) ECOLOGICAL STUDIES

Field observations on Coptotermus curvignathus — A large Kempas tree (*Koompassia malaccensis*) which had been felled five months previously in the new clearing on the Experiment Station was found to have its hollow centre completely replaced by the workings of *Coptotermus curvignathus*. Cutting the fallen trunk into sections revealed a succession of carton-like nest structures closely applied to the inner surface of the wood, embedded in a porous earthy material. Water could be squeezed out of the latter, suggesting that its function was principally to maintain the high humidity which termites require. As no immature stage were found the inference was that the reproductives were located somewhere in the stump. To cut this open would have been a formidable task. An attempt to split the wood or overturn the stump with gelignite charges met with no success.

Survey of attacked trees — Since early 1946, when routine control measures were re-introduced on the Experiment Station, treated trees had been given a distinguishing mark. A survey of these marked trees has been carried out in the hill section of the plantation, where the land was cleared from jungle without burning or with only a light burn, and where natural covers are in consequence dense. In the clean cleared areas termite attacks have never been serious. The objects were: to provide information on the distribution of termites; to estimate what economy might be possible in distributing insecticides to eradicate them; to investigate the possibility of locating nests within limits; and lastly, to

bring out any differences which there might be in clonal susceptibility.

Plotting the results has built up a picture of scattered attacks over a wide area, rather than of isolated islands of attacked trees in the vicinity of nests. Somewhere between a third and two thirds of the area of different fields might have been regarded as free of the pests for purposes of an eradicant campaign, provided that work was based on plots of about 1/10 acre. There was no indication of any marked susceptibility or resistance of certain clones.

VIII(2) OBSERVATIONS ON CHEMICAL CONTROL

Routine control measures — Monthly records relating to incidence and cost of control of termites on the Experiment Station have been maintained, field by field, since 1946. No obvious trends in incidence have been observed apart from an initial decline following the re-introduction of control measures after the occupation.

In October 1947 the method of control was changed from the crater method (using Cymag and sodium silicofluoride) to the liquid method using 1% mercuric chloride, as it was considered that there would be a saving in labour. Moreover, damage to roots during excavation of the collar would be avoided. Until the end of 1948 a regular monthly round of inspection and treatment was operated in the attacked fields. Since then it has been arranged that the tappers report cases as they occur, and a labourer is sent to apply the treatment. That the revised procedure effected a considerable economy is shown by the following approximate figures. Before the change, labour costs of $3.00 per acre per year for inspection and treatment were little affected by the incidence of attack. Following the new procedure, labour is roughly proportional to incidence, which ranges from 0.1 to 1.5 cases per acre per month, with an average of 0.5. Over the whole area the labour charge has been 11 cents per treated tree, equivalent to $0.70 per acre per year. To this must be added the cost of the poison at 5 cents per tree (1 pint of a 1% solution of mercuric chloride) making the total cost of labour and materials roughly $1.00 per acre per year.

Comparison of control methods — In addition to the two control methods referred to above there was a third which received attention before the war—trail injection with white arsenic. Comparative costs and effectiveness were obtained from experiments

conducted in 1937-9.* With supplies of white arsenic again becoming available a further trial has been started in three fields on the Experiment Station, to obtain comparable figures under present conditions.

Experiments with dusts liberating hydrocyanic acid — The report for 1948 referred to an experiment laid down on an estate to test the value of injecting Cyanogas into trees hollowed by termites, as an addition to the routine use of mercuric chloride. This experiment had to be discontinued, as the number of trees which could be treated with Cyanogas proved in the event to be smaller than was anticipated. It was not possible to discern any reduction in incidence of attack in the field where Cyanogas was used, when compared with the field treated with mercuric chloride alone.

IX

COCKCHAFERS

The plan to study all known sites of cockchafer attack was abandoned, owing to the disturbed state of the country, after the visits already reported to sites in Kedah and Pahang. Evidence of changes in the status of the pests must now come from advisory correspondence. During the year only one report of an outbreak was received from an estate in Kedah. It was of particular interest in that the species concerned was *Psilopholis vestita,* encountered for the first time since the war. Cockchafers were found on one other estate, also in Kedah, where an experiment was laid down in 1948.

IX(1) BIOLOGICAL STUDIES

Scoliid parasites — Specimens of three species of Scoliid wasps were collected in Kedah visiting flowers of Belimbing (*Averrhoa bilimbi*). They have been identified by the Commonwealth Institute of Entomology as *Campsomeris peregrina* Lep. var. *quadriguttulata* Burm., *C. indica* Sauss., and *C. pseudojavanica* Betrem. Only males of the last named were found; the others were females. *C. quadriguttulata* Burm. has been recorded as parasitising *Leucopholis rorida* and *Lepidiota stigma,* both of which occur in the area, the former being the species most commonly met with.

Psilopholis vestita — A local outbreak of *Psilopholis vestita* was discovered on an estate in Kedah, attention having been

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drawn to the area by the activities of wild pigs which were breaking bunds and terraces in their search for the larvae. About four acres were affected, under twenty year old rubber on a steep hillside. In all probability the infestation had been established by beetles which had flown in from the jungle which, at the nearest point, was only about 100 yards away across a small ravine.

From the number of larvae found in survey pits the population density was estimated at 35,000 per acre—a moderately high figure. Among nearly 100 larvae collected one was found dead, attacked by a fungus which was perhaps parasitic; another, which was still active, showed symptoms suggestive of a bacterial disease. As no Scoliid or Tachinid was encountered it is possible that the outbreak developed because of the local disappearance of these more important natural enemies.

IX(2) STUDIES CONCERNED WITH POPULATION TRENDS

Incidence on an estate in Kedah — In an area where the rubber was stunted from prolonged cockchafer attack a tree was excavated to expose the tap root and main laterals. Fourteen adults (all *L. rorida*) four pupae and two larvae were found. Nearby stood a tree which on similar excavation a year before was found to carry about the same cockchafer population. It thus appears that an attack of low intensity has been maintained unchanged in this area from one generation to the next.

IX(3) THE INVESTIGATION OF CONTROL MEASURES

Field trial of soil insecticides — An experiment was laid down during November 1948 on an estate in Kedah to test the protective value of various insecticidal dusts when incorporated in the planting soil. The layout was based on results of a grub survey made when the planting holes were dug, the area chosen having a reasonably high and uniform population. Planting had been delayed in order to avoid damage from the larvae then nearing full growth. Results were expected when the next generation of cockchafers developed during 1949, but this attack failed to materialise. There were no differences in growth between the treated and control plots, and the losses which were sustained were found to be attributable to drought. The trial therefore yielded no result. The failure of this experiment, which was put down in the only place known to be infested, gives the clearest indication of the low level to which cockchafer attacks have fallen.

Light trap — An experimental light trap designed to work with a pressure paraffin lamp was set up on the same estate. Although the beetles flew to the lights in the Manager's bungalow they were not attracted to the trap. Of various factors which might have accounted for this failure of the light trap the most likely seemed to be the height above ground. Beetles were observed to fly above the tree tops; thus they frequently collided with the roof of the factory (near where the trap was operated) and perhaps for this reason too they entered the bungalow, which is situated on a small hill.

X

MITES

Biological studies of the acarid fauna of rubber have been continued. Of less importance than the yellow tea mite (*Hemitarsonemus latus*) are certain red spider mites (Tetranychidae) and a mite which has been identified as a species of *Brevipalpus* (Pseudoleptidae). They have all been reared in the laboratory.

X(1) BIOLOGICAL STUDIES

Predators of Hemitarsonemus latus — Three predators have been found to attack the yellow tea mite. The one of most significance in the natural control of the pest is undoubtedly the Laelaptid discussed in the last report. Provisionally regarded as a *Typhlodromus*, it differs from the two species already recorded on rubber— *T. heveae* and *T. hevearum*, both from Medan, Sumatra.

Next in importance is a thrips identified by the Commonwealth Institute of Entomology as a species of *Taeniothrips*, probably *T. thunbergiae* Karny, which is thought to be a synonym of *T. minor* Bagnall. It has been found to attack not only *H. latus* but also the rubber thrips *Scirtothrips dorsalis* (see below).

The last is a gall midge, the larvae of which is a most efficient predator; but it has been rarely found and has not been identified.

Tetranychid mites — Red spider mites which are found on rubber have been bred through the complete life cycle in the laboratory on leaf sections. Earlier attempts to rear them on young leaflets inverted on wet filter paper, as employed for breeding *H. latus*, were unsuccessful; it was found however that they would live when kept on the upper leaf surface. Very young leaves could not be used in this way as they rapidly became mouldy when the

lower surface was in contact with water, but the method was successful using small squares cut out of mature leaves.

Pseudoleptid mites — Mites of the genus *Brevipalpus* are commonly found on rubber leaves, but not in sufficient numbers to constitute a pest. They too have been bred in the laboratory following the procedure used for Tetranychids except that the lower leaf surface was presented to the mites. Although the life history data obtained are open to some doubt on account of excessive mortality in all stages, it is clear that *Brevipalpus* has a much slower development than *H. latus*, and this probably explains its slight importance to the plant. Thus at laboratory temperatures the egg stage lasts about seven days, whereas the life cycle of *H. latus* is completed in five. The remaining developmental stages (larva, protonymph, deutonymph) require about four or five days each.

A Coccinellid predator — The larva of a ladybird beetle was observed to attack Tetranychids on rubber leaves, but was lost before becoming adult.

XI

OTHER INSECT PESTS

(1) THYSANOPTERA

Identification of the Hevea thrips — Specimens of thrips attacking rubber, regarded as *Scirtothrips dorsalis* Hood, have been returned from the Commonwealth Institute of Entomology with the specific identity confirmed. The opinion was expressed, however that *Scirtothrips* Shull should be regarded as a synonym of *Sericothrips* Hal.

Thrips damage — A chance outbreak of *S. dorsalis* on a small experimental plot of seedlings provided an opportunity of studying the damage caused by this pest when unassociated with any other. Two symptoms were observed. On young leaves, a uniform down curving of the leaflet edge produced a scoop-like effect. Older leaves frequently were strongly asymmetric, one side of the leaflet blade being more or less suppressed with consequent approximation of the secondary veins with the midrib along part of their length, this being accompanied by a curving of the midrib in the plane of the leaflet.

XI(2) HEMIPTERA

Coccids attacking rubber — Seedling specimens sent in by estates were commonly attacked by one or other of three species *Ferrisia virgata* (Ckll), *Saissetia nigra* (Nietn.), *Pulvinaria maxima* Green. The last named was sometimes found to be parasitised by the fungus *Hypocrella* sp.

Predators — Three larval predators have been observed attacking Coccids on rubber. A Lycaenid identified as *Spalgis epius* Westwood, which is already known to be predacious on Coccids in this region, was found feeding on eggs and ovisacs of *P. maxima.* A Cecidomyid larva attacked eggs of the same species, and an unidentified mealy bug was attacked by a Coccinellid larva.

Control measures — A local outbreak of *S. nigra* in an estate nursery provided an opportunity of comparing an oil spray with Parathion. The treatments were applied to two adjacent beds containing roughly 500 plants about equally attacked; the affected area was not large enough to provide for untreated controls. The sprays were Shell White Oil and Fosferno 20, at dilutions of 2.5% and 0.03% by volume respectively. Using a Knapsack sprayer six applications were made at weekly intervals, the scale population being assessed by weekly counts. No significant difference in effectiveness was found, both treatments giving a satisfactory control. Although the tests were on too small a scale to be conclusive, the results suggest that an oil spray, being effective yet non-toxic to man, is to be preferred for the control of the black scale.

XI(3) COLEOPTERA

Beetles attacking seeds — Nitidulid beetles (Carpophilus sp.) were found in rotted seed of clone BR 2. As the seed coat had been cut at the micropylar end to facilitate germination, it is presumed that the beetles gained entry in this way.

Fungivorous beetles — A collection was made of insects inhabiting fructifications of *Fomes lignosus,* in connection with an inquiry into the mechanism of transmission of the fungal spores. Almost all were Coleoptera, mostly Tenebrionids.

XI(4) LEPIDOPTERA

Tiracola plagiata — An outbreak similar to those described in the Annual Reports for 1937, 1938 and 1939 was reported in a new clearing of an estate in Johore. Natural covers were defoliated over an area of two hundred acres; the pest then extended its attack to the young rubber seedlings, causing considerable damage.

XI(5) PESTS OF COVER CROPS

Coleoptera — There have been several reports of outbreaks of *Epilachna indica* on cover crops. A Eumolpid, identified as *Pagria signata,* was found feeding on a mixed cover of *Centrosema* and *Calopogonium.*

Hemiptera — Other insects found on the mixed *Centrosema* and *Calopogonium* have been identified as *Homoeocerus serrifer* (a Coreid), *Haltica minuta* (a Capsid), and *Coptosoma siamicum* (a Pentatomid).

XII

NEMATODES

Although it is known that estates are beginning to establish leguminous cover crops—from the requests which we receive for cultures of root nodule bacteria—we have yet to receive the first report of eel worm attack since the war. In the meantime no work is being undertaken under this heading.

XIII

OTHER ANIMAL PESTS

Young seedlings planted in the field are vulnerable to attack by rats and squirrels and it is not always possible to be sure which pest is to blame. New plantings from jungle, and areas under dense natural covers, are the most liable to attack. The seed seems to be the main attraction, losses falling off as the seedlings become established. For this reason the provision of temporary protection by some improvised type of guard may be preferable to poisoning or trapping.

Isolated reports have been received of damage by monkeys and porcupines in new clearings.

Pigs and deer may be troublesome on estates near jungle where fencing is not employed. To provide a sufficiently strong fence may not be economic; electric fences, which are cheaper to erect, have not been well reported on. Their function is to enclose domestic animals rather than exclude wild ones. It is therefore necessary to resort to other methods of control; for pigs the best solution seems to be poisoning; for deer, repellents are indicated,

and inquiries have been received as to materials which could be used. Many years ago considerable success was claimed for a mixture of about equal parts of whale oil and tar; recently a new proprietary material has been marketed in the United States, where it has received very favourable reports. Supplies are being obtained with a view to carrying out tests on rubber.

XIV

INSECTICIDES

The heavy rain experienced in Malaya gives added importance to the use of stickers with insecticides and fungicides. Following up the observations made last year, when it was found that up to 2% of slaked lime could safely be added to a lead arsenate spray, an experiment has been carried out with this and three other sticking agents.

Effect of sticking agents on the tenacity of a lead arsenate spray — The effect of addition of four sticking agents—acid serum, fresh and ammoniated latex, all at 0.2%, and 0.5% slaked lime—on the amount and tenacity of the deposit produced by a 0.5% lead arsenate spray has been determined experimentally. Each formulation under test was sprayed on to selected leaves of five nursery seedlings with a small pneumatic hand sprayer, each plant receiving the spray for a timed period of two seconds. Leaf samples consisting of one complete leaf from each plant were taken as soon as the spray deposit was dry. A second set of samples was collected on the following day, after a rainfall of 1.93 inches. The samples were then handed to the Soils Division where they were air dried for three days, milled and passed through a 30-mesh screen, the midrib and larger veins being discarded. Arsenic was determined on duplicate 0.5 gram portions by the molybdenum blue method. The results are tabulated in TABLE XV, from which it appears that addition of 0.5% slaked lime has a distinctly adverse effect on the amount of the initial deposit and, further, that it does little to improve tenacity. Taking both factors into consideration, 0.2% fresh latex would seem to have been the only addition that brought about a positive improvement. However, since this trial was carried out on nursery plants, and sampling errors may have been large, it is considered that no final conclusions should be drawn until the experiment has been repeated with potted seedlings.

TABLE XV: EFFECT OF STICKING AGENTS ON THE AMOUNT AND TENACITY OF THE DEPOSIT PRODUCED BY A 0.5% LEAD ARSENATE SPRAY

Sticking agent added to 0.5% lead arsenate spray	*Arsenic as p.p.m. As_2O_3*		*Percentage retained*
	in initial deposit	*after 1.39 inch rain*	
None (control)	361	101	27.9
0.5% *Ca (OH)$_2$*	177	57	32.2
0.2% *fresh latex*	433	178	41.1
0.2% *ammoniated latex*	250	97	38.8
0.2% *acid serum*	348	93	26.7

XV

ROOT NODULE BACTERIA

Thirty nine tubes of root nodule bacteria cultures for the inoculation of cover crop seed were distributed to estates during the year. In almost all cases the cultures were required for either *Centrosema pubescens* or *Pueraria javanica.*

Further *Rhizobium* isolations have been made from *Centrosema* and *Pueraria* nodules, and the cultures tested in the laboratory. Only cultures of proved efficacy in forming nodules and fixing nitrogen are used for distribution.

Preparations have been made for an experiment to compare various methods of inoculating seed.

ADVISORY WORK AND OTHER ACTIVITIES

ADVISORY CORRESPONDENCE INCREASED by almost a half over last year, with 997 letters despatched. Nearly twice as many specimens were examined—626, of which rather more than half were of secondary leaf fall. Visits to estates and smallholdings, and interviews, were little changed from last year at 95 and 124 respectively. The graduate staff also made 245 visits to the Experiment Station.

Circulars and *leaflets* — The following circulars and leaflets were issued during 1949:

P/AL.1(49) The control of root disease in young rubber

P/AL.4(49) Treatment of fire damage

P/AL.5(49) Notes on sulphur dusting

P/IN-1(49) Fungicides approved for use in the treatment of mouldy rot

P/IN-3(49) Observations on the treatment of mouldy rot

P/IN-4(49) Further observations on the treatment of mouldy rot

A note on poisoning and root disease was prepared for Circular No. 29*

Stump Poisoning and Root Disease

Importation of budwood — Two consigments of budwood were imported by the Institute during the year: 20 yards of clone L.C.B. 870 from the Rubber Research Scheme, Ceylon; 70 metres of clone L.C.B. 1320 from the Proefstation van de Centrale Proefstations Vereniging, Bogor. The consignments were accompanied by the appropriate certificates of inspection, treatment, and freedom from disease. Before shipment the budwood was dusted with sulphur and packed in sterilised coconut fibre. On receipt the boxes were opened in the Pathological Division, again inspected, and disinfected by momentary immersion in a 0.2% solution of mercuric chloride in 50% methyl alcohol. The packing materials were immediately burned, as were the remains of the budwood after budding had been completed.

ARTHUR NEWSAM
Acting Head of Pathological Division

Kuala Lumpur
November 1950

* Superceded: *Planters' Bulletin* (1952)3 and Circular No. 36

PATHOLOGICAL DIVISION 1950

RUBBER RESEARCH INSTITUTE OF MALAYA
KUALA LUMPUR

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STAFF

DR A. NEWSAM (ENTOMOLOGIST) CONTINUED TO ACT as Head of the Division until 28 November when the writer assumed duty on his return from the United Kingdom. Mr F.W. Hutchison (Field Research Officer) and Mr K.P. John (Assistant Pathologist) were on duty throughout the year. Mr R.N. Hilton (Pathologist) was released for service with the Security Forces during the month of March, and was subsequently seconded for full time duty as a Resettlement Officer from 22 June until 16 December.

During September and October the Head of the Division paid a visit to America with the two-fold object of gaining information as to the steps that are being taken to combat South American leaf blight in the western hemisphere, and of negotiating an exchange agreement with the Director of the Instituto Agronomico do Norte, Belem Para. During the course of this tour visits were paid to the United States, Brazil, Panama, Costa Rica and Trinidad.

The Entomologist's occupation with the duties of Head of the Division for eleven months of the year led to some curtailment of the research on entomological problems.

ACKNOWLEDGEMENTS

FOR ADVICE AND ASSISTANCE in connection with various aspects of the problem of disseminating a defolint from the air we are much indebted to Dr S.P. Wiltshire, Director of the Commonwealth Mycological Institute; Professor G.E. Blackman, Professor of Rural Economy, University of Oxford; Lt Col H.J. Holman, Secretary to the Colonial Insecticides, Fungicides and Herbicides Committee; and the Chief Superintendent, Chemical Defence Experimental Establishment.

The writer would like to take this opportunity of recording his appreciation of the generous assistance received from the following during the course of his visit to the western hemisphere: Dr R.D. Rands and other officers of the U.S. Department of Agriculture, Washington, D.C.; Dr F.C. de Camargo, Director, and other officers of the Instituto Agronomico do Norte, Belem Para; Dr M.H. Langford, Dr E.P. Imle and other officers of the Division of Rubber Plant Investigations, U.S.D.A., in Costa Rica; Mr Walter Lindsay and Mr J.T. Mitchell, Office of Foreign Agricultural Relations, U.S.D.A., Canal Zone; Mr E.W. Leach, Director of Agriculture, Trinidad; Professor C.Y. Shephard, Acting Principal, Professor R.E.D. Baker and other members of the staff of the Imperial College of Tropical Agriculture, Trinidad.

INVESTIGATIONS

I

DISEASES OF THE ROOT SYSTEM

An analysis of the monthly reports received from the Smallholders' Advisory Service has shown that root disease was evident in about 3 per cent of the 55,000 smallholdings visited during the year.

The majority of the inquiries received during the year were concerned with the control of root disease in young replantings. Information was also sought on methods of control prior to replanting, interest being centred in particular on stump poisoning.

A fungus which produces rhizomorphs indistinguishable in the field from those of *Fomes lignosus* has been identified as *Polyporus rugulosus* Lev*. It was found growing on the dead roots of stumps that had been poisoned with sodium arsenite. Inoculation experiments have shown the organism to be non-pathogenic to Hevea rubber.

I(1) STUDIES CONCERNED WITH THE GROWTH, PATHOGENICITY AND DISPERSAL OF THE THREE MAJOR ROOT PARASITES

Factors affecting the pathogenicity of Fomes lignosus — All attempts to study this problem in the laboratory by observations based on young potted seedlings have been nullified by consistent failure to secure infection of the plants either with pieces of naturally infected roots or with pure cultures. That the natural inocula should have failed to transmit the disease is particularly surprising since in previous experiments no difficulty has been experienced in infecting the roots of mature trees with the aid of similar material.

In the hope that the inoculations might succeed if the plants were grown under more favourable conditions, a number of seedlings were raised in a glasshouse in 10-inch pots containing well manured soil into which pieces of infected root had previously been introduced. However, no signs of disease were apparent at the end of the year, by which time the plants were five months old.

Relation of the spores of Fomes lignosus to the spread of root disease — Work on this problem has been continued. *Fomes lignosus* has been induced to grow and produce rhizomorphs on short

* *We are indebted to the Forest Products Research Laboratory, Princes Risborough, for the identification of this fungus.*

lengths of freshly cut young rubber stems that were inoculated with its spores and incubated in a moist chamber. Although the conditions of this experiment were somewhat artificial, when its results are considered in conjunction with those recorded last year it is to be seen that some support has been obtained for the suggestion that the stump of a healthy rubber tree may become invaded by *F. lignosus* through infection of its cut surface by airborne spores. It is proposed however to continue these studies in the hope of obtaining more convincing evidence in support of this hypothesis.

I(2) STUDIES CONCERNED WITH THE IMMEDIATE PROBLEM OF ROOT DISEASE CONTROL

Rate of loss of infectivity by fragments of diseased roots — The object of this experiment (whose plan was described in last year's report, page 12) is to determine for what length of time a piece of diseased root remains infectious when buried in the soil. The results obtained during the first twelve months of observation are summarized in *Figure 1.*

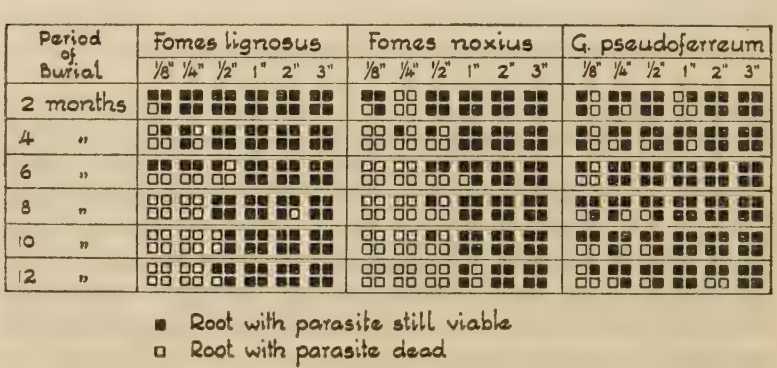

Figure 1. Survival of the parasites in diseased roots; the roots ranging in diameter from ⅛ inch to 3 inches and in length from 1 ft to 2 ft. The results given by the shorter roots are shown on the left on each column.

It will be observed that only the smallest roots infected by *Fomes lignosus* and *Fomes noxius* had ceased to be infectious by the end of a year; and that the rate of loss of infectivity varied with the parasite and was in the descending order: *Fomes noxius —Fomes lignosus—Ganoderma pseudoferreum.*

The ⅛- and ¼-inch roots that had been infected by *Fomes lignosus* were found to have disintegrated entirely after twelve months' burial.

Field study of the economics of root disease control — Two rounds of inspection and treatment have been completed in the experiment laid down on Pataling Estate.* These have shown that the incidence of root disease in the experimental area is extremely low; so low in fact that it is doubtful whether the experiment would be worth continuing.

Evaluation of various methods of stump poisoning — The experiment laid down at Sungei Buloh in 1949 was completed during the year. But for the omission of treatment *C*, and some modifications in the sampling technique (which were described in the previous report), this was in effect a repetition of the experiment that had been carried out on Pataling Estate in 1948.

Four treatments were compared, each being replicated four times. These were as follows:

A The poison introduced through one-inch auger holes bored from the outside of a high cut stump inwards and downwards over the laterals.

B The poison introduced through one-inch auger holes bored in the cut surface of a low-cut stump, downwards and radially outwards towards the laterals.

D The poison poured into the fissure left on the cut surface of the stump after felling.

E Control—no treatment.

Each treated stump received 15 oz of sodium arsenite in the form of a 10 lb : 1 gallon solution.

The results of the analyses of the root samples, which were carried out by the Soils Division, are given in TABLE I. It will be seen from the above figures that despite improvements in technique the results still lack regularity. Nevertheless they do indicate that methods *A* and *B* provide more effective means of introducing the poison into the laterals than method *D*. This is not entirely in keeping with the results obtained in 1948, when there was found to be little to choose between *B* and *D*.

As an outcome of the experience gained from these two trials the conclusion was reached that it was unlikely that a completely satisfactory procedure for evaluating methods of stump poisoning could ever be developed from a study of the distribution of arsenic in the roots. It was therefore decided to attempt to assess the treatments by direct observations on the rate at which they brought about the death of the roots.

With this object in view an experiment was laid down during the course of the year on Galloway Estate in an area of old rubber

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TABLE I: DISTRIBUTION OF ARSENIC IN THE LATERAL ROOTS OF POISONED STUMPS

p.p.m. As_2O_3 in oven dry samples

Treatment	*Distance of sample from bole*	*Time of sampling*			
		1 day	*3 days*	*6 days*	*12 days*
A	1 ft	165.0	427.5	820.8	453.8
	3 ft	12.8	255.6	142.8	186.5
	6 ft	38.5	41.3	16.3	13.5
B	1 ft	58.0	152.5	38.3	1457.0*
	3 ft	26.0	282.5	60.5	770.3*
	6 ft	5.3	701.8	126.5	67.3*
D	1 ft	7.3	32.3	7.3	41.5
	3 ft	6.5	9.3	13.0	23.8
	6 ft	4.5	5.8	6.0	22.5
E	1 ft	3.0	4.0	3.5	5.0
	3 ft	2.8	4.8	3.5	3.0
	6 ft	2.0	4.5	3.5	3.5

* *These figures are based on three replications only, as one stump in this treatment had only three laterals. All other figures are means of four replications.*

that was in the process of being felled for replanting. This has been designed in such a manner that it will ultimately be possible to compare the original assessments (based on the rate of death of the roots) with a later series based on the relation between the treatments and the incidence of root disease in the replanted stand.

Seven treatments are being studied in this experiment, each of which has been replicated six times on half acre plots. Four of of the treatments are the same as those detailed above as *A*, *B*, *D* and *E*. To these have been added two stump poisoning treatments and one protective treatment, which are as follows:

F A ring of bark about 6 inches wide removed from the top of the stump and the newly exposed surface painted with a 10 lb: 1 gallon solution of sodium arsenite made into a paste with tapioca starch, the application being adjusted to give about 15 oz of sodium arsenite a stump.

G As above but the paste made from a 5 lb: 1 gallon solution of sodium arsenite and applied at the rate of 1¼ oz of sodium arsenite a stump.

H The cut surface of the stump sprayed with a proprietary tar oil wood preservative.

This last treatment is intended to examine the question whether a healthy stump can become invaded by a root disease parasite as a result of infection of its cut surface by spores. If this hypothesis is correct, it should be possible to immunize the stump by protective treatment.

The cost of carrying out the treatments varied considerably, as will be seen from the data in TABLE II.

TABLE II COST OF EXPERIMENTAL STUMP TREATMENTS

CONDITIONS

Stand: 90 *trees an acre*
Wages: $1.60 *a day*
Cost of materials
Sodium arsenite: $45.00 *per cwt*
Tapioca starch: 30 *cents per lb*
Wood preservative: $ 3.60 *a gallon*

DETAILS OF COSTS IN DOLLARS

Treatment	*Cost per acre*			*Cost per stump*
	Labour	*Material*	*Total*	
A & B. 15 oz sodium arsenite introduced through augar holes	19.70	33.00	52.70	0.59
D. 15 oz sodium arsenite introduced through fissures	0.53	33.00	33.53	0.37
E. Control. No treatment.				
F. 15 oz sodium arsenite painted on to barked surface	3.20	33.15	36.35	0.40
G. 1¼ oz sodium arsenite painted on to barked surface	3.20	2.95	6.15	0.07
H. Cut surface sprayed with wood preservative	0.27	8.00	8.27	0.09

Tolerance to arsenic of the three major root parasites — The minimum concentration of arsenic (as As_2O_3) necessary to inhibit the growth of *Fomes noxius* on potato dextrose agar having now been determined, this study has been brought to a close. The results obtained with *Fomes lignosus* and *Ganoderma pseudoferreum* have already been reported (*Pathological Division '49*), but for the

sake of completeness these are given below together with the more recently acquired data for *F. noxius.*

TABLE III: MINIMUM CONCENTRATION OF ARSENIC AS (AS_2O_3) NECESSARY TO INHIBIT THE GROWTH OF THE THREE MAJOR ROOT PARASITES ON POTATO DEXTROSE AGAR

Parasite	*Minimum inhibiting concentration of arsenic as* As_2O_3
F. lignosus	2500 - 3000 p p m
G. pseudoferreum	1125 - 1250 p p m
F. noxius	200 - 300 p p m

This study has brought to light the fact the three major parasites not only differ in their tolerance to arsenic, but that the differences which they exhibit are of a considerable magnitude.

If the figures given in TABLE I for the As_2O_3 content of oven dry samples of lateral roots of poisoned stumps are compared with those given above, it becomes apparent that the concentration of arsenic that can be built up in roots as the result of stump poisoning is never likely to be high enough to inhibit the growth of *F. lignosus* or *G. pseudoferreum,* though it may at times be sufficient to inhibit the growth of *F. noxius.*

This finding helps to explain why poisoning cannot be relied on to neutralize active (*i e* existing) sources of infection. Furthermore, it suggests that the sole way in which stump poisoning operates—at least against *F. lignosus* and *G. pseudoferreum*—is by killing the roots and thus laying them open to invasion by saprophytes that are antagonistic to the parasites.

II

DISEASES OF THE TAPPING PANEL

(1) MOULDY ROT

Mouldy rot continued to cause trouble all over the country, both on estates and smallholdings. Since it is a disease that can be readily brought under control by the use of suitable fungicides, this state of affairs must be attributed to the existence of circumstances which prevented proper attention being paid to its treatment.

DISEASES OF THE TAPPING PANEL

From the monthly reports of the Smallholders' Advisory Service it appears that mouldy rot was present on about 8.5% of the holdings inspected during the year.

Development of an improved type of sprayer — During the year Imperial Chemical Industries (Malaya) Ltd submitted for examination a proprietary sprayer which complied fairly closely with the specification that had been drawn up in 1948 for a machine suitable for the rather special task of spraying tapping panels*. This was a knapsack sprayer of 2 gallons working capacity. Preliminary tests indicated that certain modifications would be required before this machine could be considered entirely satisfactory, a lighter lance and a more effective trigger control being particularly desirable. Furthermore, the rate of delivery at the normal working pressure of 90 p s i was found to be too high.

By substituting a 2/920 Vermorel lance fitted with a No. 5 Vermorel nozzle these faults were overcome, and a machine produced which was found to be capable, during a six hour working day, of covering about $1\frac{1}{2}$ times the acreage covered by the sprayer normally recommended for use (the Vermorel No. 5 hand pneumatic). The rate of delivery was approximately the same with both machines.

Treatment of wounds resulting from mouldy rot — The possibility of inducing the wounds caused by *Ceratostomella fimbriata* to heal over is being examined. Among a number of wounds dressings that are being tested, the petroleum grease, V.P. 2295-C, is showing the most promise.

II(2) BLACK STRIPE

Evidence is accumulating which suggests that P.B. 86 is more susceptible to black stripe than most of the other clones grown in this country. During the year under review not only was P.B. 86 involved in three out of the four cases of this disease which were brought to our notice, but in two of them it was the only clone affected. A particularly striking example of this differential susceptibility was observed on an estate in Johore, where the outbreak occurred in an R.R.I. experimental area consisting of adjacent 9-acre blocks of clones Tj. 1, P.B. 86 and Pil. B. 84 arranged in this order in duplicate. The disease was entirely confined to the two P.B. 86 blocks, no trace of it being apparent on the other two clones.

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II(3) EVALUATION OF FUNGICIDES

Preliminary fungicidal and phytocidal tests — In vitro fungicidal tests against the pathogen of mouldy rot were carried out with three flavine compounds, two coal tar dyes, and two organomercurials (R. 1412 & R. 1489) submitted by Imperial Chemical Industries. Six of these compounds were then subjected to phytocidal tests, the seventh (proflavine sulphate) being omitted because the indications were that its use would be uneconomic at effective concentrations. The results of both these tests are summarized in TABLE IV. In addition two proprietary preparations, Brunosil and Armicide, were subjected to preliminary fungicidal and phytocidal tests.

TABLE IV: PRELIMINARY FUNGICIDAL AND PHYTOCIDAL TESTS

Fungicide	*Fungicidal limit* a	*Phytotoxic limit* b
Acriflavine	0.05 %	0.5 %
Euflavine	0.01 %	0.5 %
Proflavine sulphate	0.50 %	not tested
Gentian Violet	0.05 %	10.0 %
Brilliant Green	0.005%	10.0 %
R. 1412	0.05 %	1.0 %
R. 1489	0.05 %	1.0 %

a *Minimum concentration at which growth of the pathogen is completely inhibited*

b *Concentration at which slight signs of injury to the cortex first become apparent*

Field trials against mouldy rot — Further field trials were carried out with Fixanol V.R., and these confirmed that a dye, gentian violet, which had originally been incorporated in this material as an aid to supervision, had the unexpected effect of retarding the rate at which the renewing bark became re-infected by *Ceratostomella fimbriata* after control had been secured and treatment had ceased. This effect is illustrated in TABLE V, where the results of two independent trials are summarized.

Additions to the official list of fungicides approved for the treatment of mouldy rot — Several proprietary preparations were submitted for testing in accordance with the prescribed regulations.

TABLE V: EFFECT OF THE PRESENCE OF A DYESTUFF ON THE RATE OF RE-INFECTION

Trial	*Fungicide*	*Percent re-infection after*		
		6 days	*8 days*	*10 days*
Trial A	*Fixanol* V.R.(0.25%)	0	12	20
	„ „ + *dye*	0	0	0
Trial B	*Fixanol* V.R.(0.25%)	0	20	70
	„ „ + *dye*	0	0	30

Two were found to be satisfactory, and were therefore recommended for inclusion in the list of approved fungicides and duly gazetted (G.N. 2036 of 17 August 1950). These were as follows:

Ialine White Disinfectant (a tar acid emulsion)

Proprietors: Prince Regent Tar Co. Ltd, London

Fylomac 90 (a compound of Fixanol V.R. and a dyestuff)

Proprietors: Plant Protection Ltd, London

Fylomac 90 is of particular interest as being the first synthetic fungicide to find its way on to the approved list.

III

SECONDARY LEAF FALL

During the main period of refoliation, which extended from the end of February until the beginning of May, outbreaks of secondary leaf fall are known to have occurred in every State and Settlement in the Federation other than Trengganu. On the whole the attack appears to have been milder than in the previous year.

The presence of the disease was confirmed on 120 estates and smallholdings distributed as in TABLE VI.

The majority of these outbreaks occurred in March (89) and April (26).

Two futher outbreaks of secondary leaf fall were reported after the main period of refoliation was over. These occurred during September in Johore, and were both caused by *Oidium heveae.*

III(1) STUDIES ON THE ASSOCIATED PARASITES

Observations on the incidence of the parasites — Examination of 353 representative specimens forwarded for confirmatory diagnosis yielded the following information regarding the incidence of the

TABLE VI: DISTRIBUTION OF KNOWN OUTBREAKS OF SECONDARY LEAF FALL

State or Settlement	*Number of outbreaks*
Kedah and Perlis	20
Kelantan	11
Penang and P. Wellesley	4
Perak	40
Pahang	5
Selangor	15
Negri Sembilan	11
Malacca	4
Johore	10

four parasites associated with the main annual epidemic of secondary leaf fall. It will be seen from TABLE VII that the predominance of *Oidium heveae* was not so marked in 1950 as it has been in previous years.

TABLE VII: INCIDENCE OF THE PARASITES ASSOCIATED WITH 353 CASES OF SECONDARY LEAF FALL

Parasite	*Percentage of cases in which*	
	Present	*Unassociated**
Oidium heveae	94	8
Hemitarsonemus latus	73	nil
Gloeosporium alborubrum	40	0.5
Scirtothrips dorsalis	31	nil

* *i e unassociated with any of the other three parasites.*

Observations on Oidium heveae — The monthly observations on the occurrence of *Oidium heveae*, which had been in progress since January 1948, were brought to a close at the end of the year. As a result of this three years' survey it has been established beyond any question of doubt that (in Malaya at least) *Oidium heveae* occurs in an actively sporulating condition all the year round on the young leaves both of self sown seedlings and terminal flushes. It is clearly unnecessary therefore to postulate the existence of a 'resting' stage in order to account for the survival of this fungus from one refoliation season to another. Indeed it is a little difficult nowadays to understand why it was ever felt necessary to advance such a postulate. It is to be remembered, however, that

the early work on *Oidium heveae* in this country was contemporaneous with the publication of WOODWARD'S studies on the perennation of apple mildew*, and it is suggested that, in the light of WOODWARD'S findings, it seemed reasonable to suppose that the occurrence of short periods of widespread activity followed by long intervals when the fungus was not in evidence could be most easily explained by assuming that *Oidium heveae* behaved in the same way as the apple mildew, and perennated by means of hyphae within the buds. That no evidence was ever produced in support of this theory is no longer surprising, for it is now realised that it is not the form or phase of the fungus which undergoes change during the course of the year but merely its prevalence, and that the latter is determined quite simply by the amount of suitable host tissue (*i. e.* immature *hevea* leaf) available for its growth.

III(2) STUDIES ON VARIATIONS IN CLONAL RESISTANCE

Comparative observations on four clones — An experiment has been carried out in Field 5 at Sungei Buloh to determine whether clones Pil. B. 84, B.D. 5, Tj. 1 and Avros 50 exhibit any significant differences in their susceptibility to secondary leaf fall. Field 5 was chosen for this experiment because, having been planted in 1929 as a large scale clone trial, it carries these four clones (among others) replicated four times in randomized plots of approximately one acre each.

The plan of the experiment was to determine for each clone what proportion the immature leaves shed as the result of infection bore to the total number produced, the latter figure being arrived at by recording the number of old leaves cast, per unit area, during wintering. The leaves were collected daily in yard square trays, four trays, one under each of the four randomized plots, being used for each clone.

Observations were started on 24 January when Avros 50 began to winter. The next clone to winter was B.D. 5, and this was followed by Pil. B. 84 and then by Tj. 1. The first three clones had completed wintering by the end of March, but with Tj. 1 this process lasted until 16 April. Secondary leaf fall was first observed on 1 March and had ceased to be apparent by 12 May, on which date the collection of leaf samples was discontinued.

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* WOODWARD, R.C., *Trans. Brit. mycol. Soc.* 12 (1927) 173

Although it may be thought questionable whether the canopy of one year (as represented by the number of mature leaflets shed during wintering) can be equated with the canopy of the next year (to which the immature leaflets falling during refoliation should more strictly have been related) there seems little doubt than any error arising from this assumption would be negligible in comparison with the magnitude of the differences brought out by these observations, the results of which are summarized in TABLE VIII.

TABLE VIII: RELATIVE SUSCEPTIBILITY OF FOUR CLONES TO SECONDARY LEAF FALL

No. of leaflets falling on 4 sq yards between 24 January and 12 May			*Percentage of total canopy lost as a result of secondary leaf fall*
Clone	*Mature leaflets during wintering*	*Immature leaflets during refoliation*	
Avros 50	1723	664	38.5
B.D. 5	803	319	39.7
Pil. B. 84	3124	124	4.0
Tj. 1	3484	153	4.4

It will be seen that clones Avros 50 and B.D. 5 were much more susceptible to secondary leaf fall under the conditions prevailing during the course of the experiment than were either Pil. B. 84 or Tj. 1.

Examination of the daily samples of the diseased leaves showed that all four of the associated parasites were present, but indicated that *Gloeosporium alborubrum* and *Hemitarsonemus latus* were predominant.

The disclosure that B.D. 5 (a clone notorious for its poor canopy in this country) is no more susceptible to secondary leaf fall than Avros 50 (a clone which carries a normal canopy) is particularly interesting.

The data showing that B.D. 5 bears only half the number of mature leaves borne by Avros 50 and only a quarter of the number borne by Pil. B. 84 and Tj. 1 are capable of two interpretations. It may be argued that this is merely a reflection of the extreme susceptibility of this clone to one or other of the leaf parasites, a condition which not only prevents it retaining its leaves but so weakens it that it is never able to produce more than a few of them. It may equally well be argued that its sparse canopy is due to the nutrient status of Malayan soils being unfavourable to its

normal growth. Before the first hypothesis can be accepted it is necessary to explain why, in the light of the data presented in TABLE VIII, no evidence of any unique susceptibility became apparent in an outbreak of secondary leaf fall in which all four parasites were involved.

IV

LEAF DISEASES OF YOUNG PLANTS

(1) BIRD'S EYE SPOT

This disease of young plants, which is prevalent in seedling nurseries all over the country, has continued to be the subject of special study. As a detailed account of the work is to be published elsewhere*, only a summary will be presented in this report.

Mycological Studies

Influence of various environmental factors on growth in culture — Observations have been made on the effect of sugar concentration, hydrogen ion concentration, and of temperature on the growth of *Helminthosporium heveae* on agar media.

Pathological Studies

Dissemination of the disease — The conclusion has been reached that the spores of *H. heveae* are windborne, and that air which is moving at a speed sufficient to detach them from the lesions is capable of transporting them for a considerable distance.

Conditions favouring infection — The effect of shade on susceptibility to infection has been the subject of further investigation, and the previous year's results have been confirmed. No final conclusion as to the way in which shade functions in reducing susceptibility has yet been reached, however.

Mode of infection — It has been shown that there is ample time for a primary lesion on a young leaflet to produce spores and with these re-infect the same leaflet before the development of its cuticle has advanced sufficiently to render it resistant. It has also been established that the different types of infection encountered in nature are determined not by variations in weather conditions, but by the stage of development reached by the leaf at the time of infection.

Susceptibility of clonal material — Observations made at Sungei Buloh have shown that young buddings of the recently

*HILTON, R.N. *J. Rubb. Res. Inst. Malaya* 14 (1952) 40

imported L.C.B. clones 870 and 1320 are liable to infection by *Helminthosporium heveae*. A collection of N.A.B. clones introduced from Ceylon were also susceptible to the attacks of this fungus.

Investigations on Control Measures

Field trial of fungicides and sticking agents — A further field trial of fungicides and sticking agents was completed during the year, this being the fourth that has been carried out since 1947.

As in the previous year, the experiment was laid down in the main seedling nursery area at Sungei Buloh, each treatment (of which there were thirteen including the control) being replicated three times on randomized plots, each of one twentieth of an acre.

The fungicides employed were as follows:

Perenox (50% Cu as Cu_2O) at 5 lb to 100 gallons, with the addition of three sticking agents

T.M.T.D. (50% dispersible powder) at $2\frac{1}{2}$ lb to 100 gallons

Fixanol V R. at 0.1 lb to 100 gallons

Fermate at 2 lb to 100 gallons

Zerlate at 2 lb to 100 gallons

M & B Bordeaux Mixture at the strength recommended by the makers, which is approximately equivalent to a 4:5:40 mixture

Low lime Bordeaux Mixture at 2:1:50

High lime Bordeaux Mixture at 5:6:50

Perelan (17% Cu as Cu_2O) a dust

The three sticking agents used with the Perenox were those which had shown most promise in the previous year's trials, namely 0.1% Aibolineum, 0.5% casein, and 0.2% (formic) acid serum. The two homemade Bordeaux mixtures, of low and high lime content, were included because of the superior results given by this fungicide in slide germination tests.

Treatments were carried out at weekly intervals, the sprays being applied with a Hymatic Portable Compressor at 80 p s i at the rate of 60 gallons per acre, and the dust with a hand operated rotary duster at 20 lb per acre. The use of Fixanol V.R. was abandoned early in the experiment when it became apparent that this material was injuring the foliage.

The experiment was brought to a close after fourteen rounds of treatment at seven day intervals had been given. Growth of the seedlings was estimated by recording the increment in height and final girth of 100 seedlings in the centre of each plot. Disease intensity at the end of the experiment was assessed by recording for

random samples of five plants from each plot, (*a*) the total number of leaves, (*b*) the number of lesions on half the centre leaflet of a leaf taken at random from the terminal flush, and from the penultimate flush.

Analysis of the data revealed growth gradients within the three replicated blocks greater than any effects due to the treatments themselves. Although there were indications that two treatments—Perenox at 5 lb : 100 gallons + 0.05% casein, and 4 : 5 : 40 Bordeaux Mixture—had had some effect, it could not be demonstrated statistically. Indeed the same conclusion has to be drawn from this experiment as was reached in the three previous trials: that no treatment achieved a satisfactory control of the disease.

Effect of reducing the interval between fungicidal applications — In all the field trials of prophylactics against bird's eye spot that have been conducted since 1947 (during the course of which some 20 preparations have been tested), the treatments have been applied either at 14 day or 7 day intervals. None of these treatments succeeded in controlling the disease, and it was therefore decided to carry out an experiment to see whether more frequent applications would lead to any improvement in results.

Two fungicides were employed in this investigation, Perenox and Perelan, the former being applied with a knapsack sprayer at a concentration of 4 lb to 100 gallons at the rate of 60 gallons per acre, and the latter with a rotary duster at the rate of 20 lb per acre. The applications were made at 1, 2, 3, 4 and 5 day intervals, each treatment (fungicide x interval) being duplicated on one sixtieth acre randomized plots. Untreated control plots of equal area were left between the treated plots.

The total number of applications made were as follows:

At daily intervals	...	48
Every other day	...	24
Every third day	...	16
Every fourth day	...	12
Every fifth day	...	10

The results of the experiment were assessed on the basis of leaf and lesion counts made at the completion of the trial, and one month later. The conclusions reached were that Perenox was more effective than Perelan; that the more frequent applications did bring about a greater reduction in the severity of the disease, but that no treatment effectively controlled it.

V

DEFENCE AGAINST SOUTH AMERICAN LEAF BLIGHT

The draft Phytosanitary Convention for the South East Asia and Pacific Region, which was drawn up at the Singapore Conference in 1949, had not received the approval of all the Governments concerned by the end of the year.

As mentioned in the introduction to this report, in September the Head of the Division paid a visit to Brazil to discuss with Dr F.C. de Camargo, Director of the Instituto Agronomico do Norte, the question of exchanging certain Malayan planting material for some of the *Dothidella* resistant Hevea clones which have been developed by the Instituto Agronomico do Norte in collaboration with the United States Department of Agriculture. Agreement was reached on this proposal.

V(1) METHODS OF ERADICATION

Evaluation of herbicides and defoliants — A large number of substances have been tested during the course of the year for their herbicidal value against rubber. In the earlier trials all the materials were applied as solutions, emulsions or dispersions in water. Following advice received from the Colonial Insecticides, Fungicides and Herbicides Committee to the effect that oil constitutes a more suitable vehicle for sprays disseminated from aircraft, attention during the latter part of the year was confined to materials dissolved in oils. A brief account of both series of trials, all of which were carried out against nursery seedlings, is given below.

Materials Applied in Water

Materials discarded as a result of a preliminary trial were common salt, a mixture of copper sulphate and common salt, and cupric chloride.

FIRST TRIAL

Materials	*Concentrations*
Ammate (ammonium sulphamate)	5.0% & 10.0%
Fernoxone (sodium salt of 2,4-D)	2.5%, 5.0%, & 10%
Fixanol V.R. (tetradecylpyridinium bromide)	2.5%, 5.0%, & 10%
Lotemcide (a tar acid compound)	10.0%
Sodium chlorate	2.5%, 5.0%, & 10%
Sodium dinitro orthocresylate	2.5%, 5.0%, & 10%

None of these materials appeared very promising since the seedlings, which were from eight to twelve feet high, were in all instances refoliating again within two weeks of treatment. Fixanol V.R. and Lotemcide produced the most rapid leaf fall.

SECOND TRIAL

In this trial the following materials were tested with the addition of 0.1% Teepol and 0.1% Lissapol N as wetting agents: 5% Fernoxone; 10% Lotemcide, 5% and 10% sodium chlorate; and 1.25% sodium pentachlorphenate. Fixanol V.R. was re-tested alone at 5% and 10%. The sprays were applied with a knapsack sprayer to one sixtieth acre plots at the rate of 60 gallons per acre.

The addition of the wetting agents led no important improvement in the results. Once again defoliation was most rapid in the plots treated with Fixanol V.R. and Lotemcide.

THIRD TRIAL

This trial was carried out on one hundredth acre plots, the sprays being applied at the rate of 50 gallons per acre. The materials tested were: the sodium salt of 2,4,5-T at a concentration of 1.0%, sodium pentachlorphenate at 2%, and the following in the form of water dispersible liquids at 5 lb per acre of their acid equivalents:

n-butyl ester of 2,4,5-T (37% acid equiv)
n-butyl ester of 2,4-D (30% acid equiv)
n-butyl ester of M.C.P.A. (50% acid equiv)

The best results were given by the water dispersible formulations of the n-butyl esters of 2,4,5-T and 2,4-D. These caused complete defoliation within 10 days accompanied by extensive bleeding and die back. Such refoliation as did occur did not take place for about a month. The plants treated with sodium pentachlorphenate dropped only those leaves which were well wetted, and continued to produce new leaves normally. With the sodium salt of 2,4,5-T and the n-butyl ester of M.C.P.A. refoliation was but little inhibited die back was confined to the growing point.

Materials Applied in Oils

In all the trials recorded below the solutions were applied with a low volume sprayer at the rate of 5 gallons per acre to one hundredth acre plots of twelve months old nursery seedlings.

FOURTH TRIAL

This was merely a preliminary experiment whose object was to determine the phytotoxic effects of the three oils which were to be used as solvents. These were a gas oil (Shell Diesoline), a penetrating oil (Mobil P.O.), and an oil of high aromatic content (P.Y. Sovacide).

Whilst no marked effects were obtained with any of these oils, some differences were observed. For whereas application of the gas oil merely resulted in slight scorching of the leaf margins, the other two induced some of the young leaves to defoliate. But

even these caused no permanent injury, and the plants soon recovered.

FIFTH TRIAL

The following materials at the concentrations shown were applied in each of the three carrier oils, giving a total of 18 treatments.

Materials	*Concentrations*
n-butyl ester of 2,4-D	2% & 10%
n-butyl ester of 2,4,5-T	2% & 10%
pentachlorphenol	10% & 20%

It was made evident by this trial that n-butyl 2,4,5-T was the most effective herbicide of the three tested, for although it tended to induce defoliation at a slightly slower rate than n-butyl 2,4-D, and at a much slower rate than pentachlorphenol, it caused far more permanent injury. Many of the plants sprayed with this compound succumbed, and very few of the remainder had refoliated even four months after treatment.

Neither the nature of the carrier oil nor the difference in concentration of the herbicide appeared to have any marked effect, the latter observation suggesting that the lowest concentrations used were at least not below the optima.

SIXTH TRIAL

The following mixtures were applied in each of the three carrier oils, giving a total of 6 treatments.

2% n-butyl 2,4,5-T + 10% pentachlorphenol

2% n-butyl 2,4-D + 10% pentachlorphenol

The presence pentachlorphenol increased the rate of defoliation in all treatments, and it was clear from the results obtained in the 2,4-D plots that this acceleration had an adverse effect, because most of the plants had begun to refoliate well within a month. The explanation of this effect would seem to be that the rapid leaf fall induced by the pentachlorphenol prevented translocation of the hormone.

The superiority of n-butyl 2,4,5-T was again demonstrated in this trial. Observations made four months after treatment showed that most of the plants sprayed with the 2,4-D ester had recovered, whereas many of those that had been treated with 2,4,5-T were dead, and only a small number of the remainder had refoliated.

In this experiment the nature of the carrier oil appeared to have an effect on the rate of refoliation in the 2,4-D plots, the percentage refoliation six weeks after treatment being observed to be as follows: gas oil, 100%; penetrating oil, 70%; oil of high aromatic content, 50%.

SEVENTH TRIAL

In this trial a mixture consisting of 5% n-butyl 2,4-D and 5% n-butyl 2,4,5-T was applied in each of the three carrier oils. The results were comparable with those obtained when the 2,4,5-T ester was used alone, indicating that the addition of an equal quantity of the 2,4-D ester confers no benefit. Once again the nature of the carrier oil appeared to be without significant effect.

The conclusions to be drawn from these seven trials are that of all the materials tested a solution of n-butyl trichorophenoxyacetate in a mineral oil constitutes the most effective herbicide for use against hevea rubber; and that the nature of the mineral oil used as a solvent is, within the limits of the range examined, of minor importance.

Trials with flame guns — A small scale field trial has been carried out with three types of knapsack flame guns. The most effective was one of Australian manufacture, but even with this the results obtained are not considered promising.

Experiments on the dissemination of a defoliant from the air — Following a preliminary discussion of the question of spraying rubber trees from the air that had been initiated by the Director of the Commonwealth Mycological Institute, arrangements were made for the Head of the Division to attend a meeting of the Colonial Insecticides, Fungicides, and Herbicides Committee with the object of seeking advice on certain aspects of the problem. It was explained to the Committee that from the very nature of the project it was held to be essential that the experimental work should be carried out with aircraft of a type that was already available and operating in Malaya, and would thus be on call at short notice in the case of need. With this requirement in mind the Committee reached the conclusion that consideration should be given to the use of a Dakota fitted with a single orifice emission system. This recommendation was receiving attention at the close of the year.

V(2) PROCEDURES TO ENSURE FREEDOM FROM DISEASE OF IMPORTED PLANTING MATERIAL

Disinfection of seed — A further study of the effect of disinfection with various fungicides on the subsequent germination of packed seed has been completed. Each fungicide was applied to a lot of 100 seeds, treatment being effected by shaking the seeds in a strong paper bag with an excess of the fungicidal dust. The seeds were then packed in wooden boxes in moist charocal and stored for 10

days, after which they were planted out in moist sand. The number of seeds that had germinated after a period of 30 days was used as the basis for comparison. The results of this trial are given in TABLE IX. The germination rate of the fresh, unstored seed was determined in this experiment and was found to have reached 83% at the end of 30 days. The marked difference between this figure and that given by the stored control (27%) suggests that the method of packing employed leaves much to be desired. Some of the results of this trial are at variance with those previously obtained, and this may mean that the method of packing needs to be not only improved but standardized more carefully.

TABLE IX: TRIAL OF SEED DISINFECTANTS

Treatment	*Germination % after 30 days*
Control (not disinfected)	27
Spergon	41
Copper carbonate	31
Agrosan	48
Zerlate	36
Fermate	43
Sulphur	31
T.M.T.D.	7

VI

STEM AND BRANCH DISEASES

(1) PINK DISEASE

Eight outbreaks of pink disease, five of which had occurred in stands of two to four year old rubber, were brought to our notice during the year.

The monthly returns received from the Smallholders' Advisory Service indicate that the disease was not prominent in smallholdings, since it was observed in less than 1% of those visited.

Effectiveness of control measures — The idea, which first gained currency in 1946, that the methods normally employed in the control of pink disease tend if anything to aggravate the complaint has been shown by observations carried out on the Experiment Station to be quite unfounded. In February, routine treatment of the disease was suspended in half the area of Field 17C, and in Field 43. The incidence of the disease in the untreated half

of 17C rose steadily throughout the year, and by December had reached a figure of 28 cases per acre. In the treated half the incidence remained more or less constant at about 2 cases per acre. In Field 43 the incidence rose from 3.2 cases per acre in February to 16 cases per acre in December. During the same period the incidence in a neighbouring field (No. 42) where regular treatment had been maintained fell from 4.3 to 2.0 cases per acre.

VI(2) PATCH CANKER

Patch Canker was not encountered during the year. It is of interest to record that only one case of this disease has been brought to our notice since 1946.

VI(3) DISEASES OF YOUNG SHOOTS

The few cases of die back of young shoots which came under observation during the period under review were all associated with infection by *Gloeosporium alborubrum*. In one case at least it was doubtful whether the fungus was the primary cause, the indications being that nutritional disturbances had rendered the plants susceptible to attack.

VI(4) OTHER STEM AND BRANCH DISEASES

Trametes incana was isolated from a die back of branches affecting clone P.B. 186 on an estate in Selangor. As in the case reported last year (*Pathological Division* '49, page 37), the fungus appeared to have gained entry through fractures caused by wind movement.

VII

INJURIES OF NON-PARASITIC ORIGIN

Several cases of injury diagnosed as being due variously to sun scorch, lightning, fire, and sodium arsenite poisoning were encountered during the year.

Comparison of wound treatments — Prior to 1950 only two cases of the malicious wounding of trees by cutting or stripping off their bark had been brought to our notice but as, judging from press agency reports emanating from neighbouring countries, it seemed possible that this form of subversive activity might increase, plans were made towards the end of 1949 for an experiment to determine which of a number of wound treatments would be most suitable for dealing with damage of this nature.

The experiment was laid down at Sungei Buloh early in the year under review. Eleven wound dressings were compared, each (together with an untreated control) being replicated twelve times on open circular wounds of uniform size cut on the stems of two groups of trees, namely twenty year old seedlings and twelve year old buddings. Performance was assessed on the basis of the rate of healing, which was determined by measurements made at the end of three months. Statistical analysis of these data yielded the following pooled order of merit for the two groups of observations:

1 Standard Vacuum Product 2295-C (a petroleum grease)
2 asphalt and kerosene mixture (the standard recommendation)
3 cowdung and clay mixture
4 asphalt and kerosene mixture + 3% Solignum
5 cowdung extract*
6 palm oil + 5% Mouldos
7 zinc oxide and linseed oil paint
8 Shell T.B. 192
9 Standard Vacuum Product 2295-C + 3% Solignum
10 untreated control
11 coal tar
12 a proprietary pruning mixture

The need for the information gained by this experiment was soon made apparent, becausue between April and the end of the year our advice was sought in nineteen cases of malicious damage involving several thousands of trees. In view both of its outstanding performance and of the ease with which it can be applied, V.P. 2295-C was recommended without hesitation as the most suitable dressing for this type of wound.

VIII

TERMITES

An analysis of the monthly reports received from the Smallholders' Advisory Service has shown that termites (*Coptotermes curvignathus*) were observed to be active in 1.3% of the 55,000 smallholdings visited during the year.

* *Prepared according to the method described by* M. RUBIN and H.R. BIRD, *J. biol. Chem.* 163 (1946) 393

VIII(2) OBSERVATIONS ON CHEMICAL CONTROL

Comparison of routine control measures — A comparative study of the three methods of termite control recommended before the war has been in progress since July 1949. The results obtained during the first eighteen months are discussed below. The three methods of control compared were the crater method using Cymag and sodium silicofluoride, the trail injection method using white arsenic, and the liquid method using a 1% solution of mercuric chloride. When the use of mercuric chloride was first introduced the solution was applied by injection into the mud work* but subsequently it was found to be more convenient to pour it into a runnel round the base of the tree. This is the procedure that has been recommended since the war, and it was the one used in the present investigation.

These treatments were applied to attacked trees only, the occurrence of an attack being disclosed not by routine rounds of inspection but by reports made by the tappers, the former practice having been dispensed with at the end of 1948 as a measure of economy (*Pathological Division '49,* page 41).

The experiment was laid down on three neighbouring fields of equal size, which at the time carried stands of rubber ranging in age from 11 to 14 years. For eighteen months prior to its initiation, the activities of the termites in these fields had been controlled by regular application of the liquid (mercuric chloride) method, and detailed records had been kept of the incidence of attack and of the cost of treatment. With the start of the experiment the crater method of control was introduced into one field and the trail injection method into another, leaving only the third field still under the liquid method. Records of incidence and cost were continued as before, and from the data compiled during the further period of eighteen months that the experiment has been in operation an assessment has been made of the relative effectiveness and cost of the three treatments. These data are summarised in TABLES X and XI.

The conclusion to be drawn from the figures is that trail injection with white arsenic is undoubtedly the cheapest method, and is at least as effective as that employing mercuric chloride solution.

In deciding on recommendations for general use there are, however, considerations other than price and effectiveness to be taken into account. White arsenic has the objection that its careless use can lead to bark burning on mature trees, and it is unsafe

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TABLE X: NUMBER OF TREES ATTACKED BY TERMITES IN THREE FIELDS UNDER VARIOUS METHODS OF CONTROL

Period	*Field 30*	*Field 33*	*Field 34*
(A) INCIDENCE DURING FIRST EIGHTEEN MONTHS UNDER THE STANDARD LIQUID METHOD			
Jan-June 1948	83	143	90
July-Dec 1948	71	187	85
Jan-June 1949	48	150	39
Total	202	480	214
(B) INCIDENCE DURING SECOND EIGHTEEN MONTHS UNDER:	*liquid method*	*trail injection method*	*crater method*
July-Dec 1949	62	116	71
Jan-June 1950	48	149	70
July-Dec 1950	49	103	66
Total	159	368	207
(C) PERCENTAGE REDUCTION IN INCIDENCE DURING SECOND EIGHTEEN MONTHS			
July 1949 to Dec 1950	21.3	23.3	3.3

TABLE XI: COMPARATIVE COSTS OF THE METHODS OF CONTROL IN CENTS PER TREATED TREE

Method of control	*Labour*	*Materials*	*Total*
Liquid	8	5	13
Trail injection	5	1	6
Crater	12	6	18

to use it on young plants. Furthermore, the method demands a certain skill from the operator in that the mud work or trail must be damaged as little as possible. In addition, the dust must be free flowing and injected in very small quantities, and to this end a suitable injector (albeit a simple device) must be provided.

The mercuric chloride method has none of these disadvantages. It is entirely without effect on the bark, and it requires no special apparatus or skill. For this reason we are continuing to recommend its use, bearing in mind that the cost, although double that of the white arsenic treatment, is still not heavy at ordinary incidence rates.

Use of benzene hexachloride dusts for treatment of mature trees — As the result of an experiment carried out in a heavily attacked field at Sungei Buloh, the conclusion has been reached

that a treatment which consists in applying four ounces of either Agrocide 1 or Agrocide 2 around the collar of every tree is of no value as a control measure against termites in mature rubber.

Protection of newly planted stumps — Newly planted stumps are very vulnerable to termite attack, and it is desirable to find a protective treatment. An experiment to determine whether this trouble can be overcome by mixing insecticidal dusts in the soil of the planting hole was laid down towards the end of the year. The dusts being tested are 5% D.D.T., Agrocide 2, and 5% Toxaphene.

Before this experiment was undertaken, all the dusts were tested for phytotoxicity to young rubber seedlings, and found to be harmless at the concentrations used.

IX

COCKCHAFERS

Only one case of cockchafer damage was encountered during the year. This is referred to below.

IX(2) STUDIES CONCERNED WITH POPULATION TRENDS

Occurrence in a nursery — An estate was visited in Selangor where evidence of cockchafer injury was found in a nursery planted in early December. Many plants which were conspicuously retarded were found to have had the tap root eaten away in a manner suggestive of cockchafer attack. One larva of *Leucopholis rorida* was found. It was supposed that the late planting of the nursery had saved it from more severe damage, since by December most larvae of *L. rorida* would be fully fed and ready to pupate.

X

MITES

(1) BIOLOGICAL STUDIES

Tetranychid mites — It has now been recognised that there are at least three species Tetranychids attacking rubber, and these have been reared in the laboratory.

Pseudoleptid mites — A species of *Brevipalpus* found on rubber leaves has been identified by Mr E.W. Baker of the U.S. National Museum as *B. australis* Tucker.

XI

OTHER INSECT PESTS

XI(2) HEMIPTERA

Association of Coccids with malformations — Many years ago HEUSSER* published evidence indicating that fasciation in *Hevea brasiliensis* is a genetic defect, and confirmation of his observations has recently been reported from Indo China†. The frequent association of mealy bugs with distortions of the leaf and with fasciations of the stem has raised the question whether these insects are not responsible for such malformations, but this sugestion awaits experimental proof.

XII

NEMATODES

Despite the extensive planting of leguminous cover crops that took place during the year, no case of injury due to eel worms was encountered.

XIII

OTHER ANIMAL PESTS

Several cases of damage to young seedlings in the field caused by rats, squirrels, porcupine, pigs, deer, and monkeys received attention during the year.

An opportunity occurred on the Experiment Station of testing the effectiveness of an electric fence as a protection against wild pig. A one acre nursery established near jungle where pig were

*HEUSSER, C. *Arch. Rubbercult. Ned.-Ind.* 10 (1926) 364
†BORGET, M. *Rep. Inst. Rech. Caoutch. Indoch.* (1947) 79

known to be present was surrounded by a two strand electric fence. That the fence had some deterrent effect was indicated by the fact that the worst damage occurred at a time when the charging unit failed. But even after a third electrified wire had been installed below the other two, pigs still entered the nursery when the installation was working properly.

XV

ROOT NODULE BACTERIA

Distribution of Rhizobium cultures — A total of 333 cultures of *Rhizobium* were sent out to planters during the year for the inoculation of cover crop seed. The principal demand was for strains effective on *Centrosema pubescens.*

Evaluation of media used in the inoculation of seed — The object of this experiment was to find out what medium would be most suitable for general use in the preparation of *Rhizobium* suspensions for the inoculation of cover crop seed; the constituents of the media to be studied being restricted to materials which were readily obtainable anywhere in Malaya, and their performance being assessed on the basis of their effects on subsequent nodulation and growth.

The following media were selected for trial:

A distilled water
B distilled water + superphosphate at 1½ gm per pint
C skim milk (57 gm dried skim milk in one pint of distilled water)
D skim milk + superphosphate at 1½ gm per pint
E formic acid serum* (pH 4.3)
F formic acid serum + superphosphate at 1½ gm per pint

Six suspensions of *Rhizobium* strain No. 261 were made up with the above media (at the usual rate of one slant culture to one pint of medium) and small quantities of the seed of *Centrosema pubescens* were inoculated with these at the rate of one pint of suspension to 20 lb of seed. A seventh lot of seed was drenched with distilled water to act as a control. After drying, the seven lots of seed were planted in 10 inch earthenware pots containing sterilized soil, four pots being used for each one of the seven seed treatments.

* *Formic acid serum is the residual liquid resulting from the coagulation of latex with formic acid*

After germination (when the plants were thinned down to eight per pot) the pots were transferred to a plant house, and so arranged that replications were symmetrically disposed, with the treatments randomized within replication. Growth at first was fairly uniform throughout, but later the controls could be seen to be falling behind. The plants were harvested when eleven weeks old, the number of nodules being recorded after carefully washing away the soil. The whole plants were then passed to the Soils Division for determination of oven dry weight and total nitrogen.

Analysis of the results (which are summarized in TABLE XII) was undertaken by the Statistician. Examination of the data for the 28 pots showed highly significant correlations to exist between oven dry weight and total nitrogen (+0.93); between total nitrogen and number of nodules (+0.80); and between oven dry weight and number of nodules (+0.70).

TABLE XII: EVALUATION OF MEDIA USED IN THE INOCULATION OF CENTROSEMA SEED

Treatment	*Means per pot of eight plants*		
	Oven dry weight (gm)	*Total nitrogen (mg)*	*Number of nodules*
A	13.85	316	199
B	12.37	292	150
C	14.71	331	162
D	13.21	295	169
E	16.26	363	206
F	13.35	299	153
Standard error	± 1.17	± 36	± 31
5% *sig. diffce*	3.52	108	94
*Control** (*one pot*)	10.55	174	0

* *During examination of the root systems it was found that eight plants distributed 4,2,2,0 in the four control pots had become accidentally inoculated. For this reason the controls have been excluded from the statistical analysis presented above. The data yielded by the one uncontaminated pot has, however, been appended.*

The values for the standard error of a treatment mean and the 5% level of significance of a difference between any two given in TABLE XII show that the only difference which reached this level of significance is that existing between the oven dry weights of treatment *E* (which consistently gives the highest figures) and treatment *B* (which is consistently lowest).

From inspection of the data it is also seen that growth was less following those treatments (*B*, *D* and *F*) in which superphosphate was included in the suspension medium.

The conclusions to be drawn from this experiment are that although differences between the treatments have not been reliably demonstrated—except in the one case cited—the indications are that formic acid serum is the most suitable of all the media studied, and that the presence of superphosphate in the medium has a deleterious effect.

The nitrogen content of the soil in which the experiment was conducted was determined on samples taken from each pot just prior to harvesting. There was little variation, all 28 determinations lying in the range 0.069 to 0.077% nitrogen, calculated on air dry soil. This figure is below average for Malayan top soils.

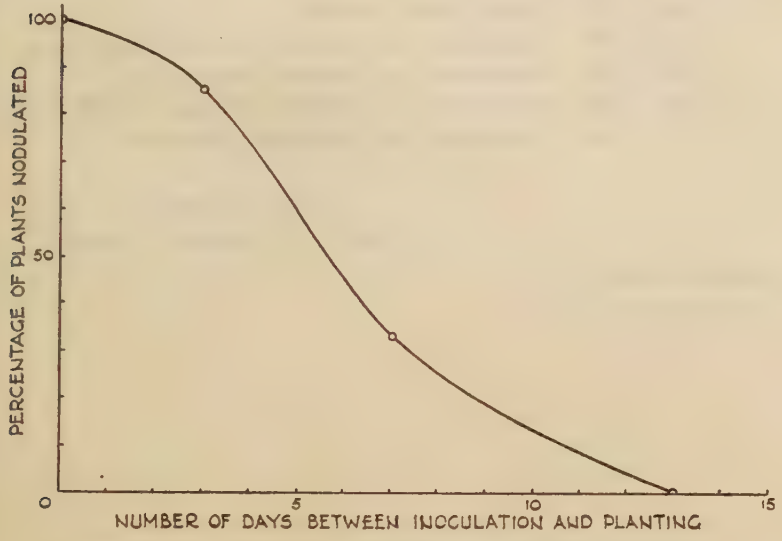

Figure 2. Effect of a delay in planting on the viability of nodule organisms on the surface of inoculated seed

Rate of loss of viability by rhizobia on the surface of inoculated seed — Surplus inoculated seed from the experiment described above was planted after increasing periods of storage in the laboratory The rate at which the percentage of nodulated plants fell off with time, as shown in *Figure 2*, indicates that the nodule organism rapidly loses its viability on air dry storage at normal temperatures, and emphasizes the importance of planting out seed as soon as possible after inoculation.

Studies on cross inoculation — *Rhizobium* strains Nos. 272, 273, and 279, which were isolated from *Pueraria phaseoloides*, were found to be capable of inducing beneficial nodulation on *Centrosema pubescens* and *Calapogonium mucunoides*. Strain 272 was also found to be effective on *Crotalaria usaramoensis*.

ADVISORY WORK AND OTHER ACTIVITIES

THE NUMBER OF LETTERS DESPATCHED from the Division during the year fell slightly to 819. Specimens sent in for examination reached a total of 504. The graduate staff of the Division paid 81 visits to estates and smallholdings, and 182 visits to the Experiment Station. Interviews at the Institute numbered 58.

Circulars and leaflets — The following circulars and leaflets were issued during 1950:

P/AL. 2 (50) Mouldy Rot (revised)
P/AL. 6 (50) Inoculation of Leguminous Cover Crop Seed
P/IN. 1 (50) Water-miscible Tar-acid Fungicides
P/IN. 2 (50) Preparation of Asphalt-kerosene Wound Paint
P/IN. 3 (50) Preparation of a Bordeaux Mixture

R.A. ALTSON
Head of Pathological Division

Kuala Lumpur
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STAFF

THE HEAD OF THE DIVISION (Mr R.A. Altson), the Field Research Officer (Mr F.W. Hutchison), the Pathologist (Mr R.N. Hilton), and the Assistant Pathologist (Mr K.P. John) were on duty throughout the year. The Entomologist (Dr A. Newsam) proceeded on home leave on 21 May.

ACKNOWLEDGEMENTS

WE ARE INDEBTED to the Commonwealth Mycological Institute, the Commonwealth Institute of Entomology, and the Forest Products Research Laboratory, Princes Risborough, for a number of identifications. For continued assistance in connection with the aerial spraying project our thanks are due to Professor G.E. Blackman, Professor of Rural Economy, University of Oxford; the Chemical Defence Experimental Establishment, Porton; and the Department of Civil Aviation, Malaya.

INVESTIGATIONS

I

DISEASES OF THE ROOT SYSTEM

Analysis of the monthly reports received from the Smallholders' Advisory Service has shown that root disease was evident in 2.6 per cent of the 54,000 smallholdings visited during the year.

The majority of the inquiries received during the period under review were concerned with measures for dealing with root disease during the course of replanting.

I(1) STUDIES CONCERNED WITH THE GROWTH, PATHOGENICITY, AND DISPERSAL OF THE THREE MAJOR PARASITES

Factors affecting the pathogenicity of Fomes lignosus

Observations on seedlings growing in pots — As none of the sixteen seedlings which had been raised in the glasshouse in pots containing pieces of infected root (see *Pathological Division '50*, page 5) had displayed any outward signs of disease after six months growth, a number of them were removed from the pots and examined. It was found that *F. lignosus* had developed freely from

the inocula, and had overgrown the roots of several of the plants without, however, causing any infection. In one a tap root had actually grown through the inoculum and emerged completely unharmed. The fungus in this inoculum was re-isolated, and thus shown to be still viable.

Since it is well known that quite young seedlings can be infected and destroyed by *F. lignosus* in a nursery, this was a most puzzling result; and it could only be concluded that some factor was operating under the experimental conditions employed which had the effect either of increasing the resistance of the host, or of reducing the pathogenicity of the parasite.

There was no indication what this factor was. It seemed unlikely that it could be soil temperature, because observation showed that the temperature of the soil in the pots in the glasshouse differed only slightly from that of soil in the open, being on the average about 3C° lower. To determine whether insolation was in any way involved (in view of the fact that the roof was constructed with 'non-actinic' glass) some of the pots were removed from the glasshouse and sunk into soil in the open. This treatment produced no apparent effect, and when the plants were a year old both those in the open and those in the glasshouse were lifted and examined. None was found to show any signs of infection. The majority of the inocula had disintegrated and, except with two plants where some dead superficial mycelium was found on the tap roots, no trace of *F. lignosus* was to be seen either on the roots or on the sides of the pots. Indeed the conditions in the pots were such that the fungus was unable to survive once it had exhausted its original food supplies.

Observations on seedlings growing in a nursery — Early in the year, when it was beginning to appear that one more attempt to inoculate potted seedlings was about to prove a failure, a number of three and six months old seedlings established in a nursery were inoculated with *F. lignosus* by inserting pieces of infected root into the soil in which they were growing.

The first indication that this experiment was succeeding became apparent about four months after the inoculations had been made, when one of the experimental plants fell over because the whole of its tap root had been rotted away. This plant showed no external signs of infection whatsoever, but most of the other inoculated plants which subsequently succumbed gave a preliminary warning of their condition by developing characteristic symptoms in their foliage.

The experiment was brought to a close (by removing all the inoculated plants that still survived) ten months after its initiation. During this period out of the 63 seedlings that had been inoculated, 27 became infected. It is interesting to compare this result with that obtained with the potted seedlings referred to above, where 16 plants were inoculated without one becoming infected. Were an explanation of this difference forthcoming it would no doubt throw considerable light on the nature of the factors which determine the pathogenicity of *Fomes lignosus*.

Relation between the volume of the inoculum and successful inoculation — The pieces of infected root used for the inoculation of the nursery plants in the experiment just described ranged in size from segments with a volume of 42 cubic inches to segments with a volume of 0.04 cubic inches. A study of the results that were obtained has disclosed the interesting fact that the chance of an inoculation succeeding varied directly with the volume of the inoculum. This is shown by the data presented in TABLE I.

TABLE I: RELATION BETWEEN VOLUME OF THE INOCULUM AND SUCCESSFUL INOCULATION

Volume of inoculum (cubic inches)	*Number of inocula used*	*Successful inoculations*
5.0 *and greater*	15	100%
Less than 5.0 *but greater than* 1.0	13	69%
1.0 *to* 0.5	9	22%
Less than 0.5 *but greater than* 0.25	8	12%
0.25 *and less*	18	nil

I(2) STUDIES CONCERNED WITH THE IMMEDIATE PROBLEM OF ROOT DISEASE CONTROL

Rate of loss of infectivity by fragments of diseased roots — The plan of this experiment was described in *Pathological Division '49* (page 12). Its object is to determine for what length of time a piece of diseased root remains infectious when buried in the soil. The experiment has now been in progress for two years. The results obtained during the first twelve months of observation were

summarized in last year's report (*Pathological Division '49* page 6) but in order to make the record complete these are again presented in *Figure 1* together with the data acquired during the second year of observation.

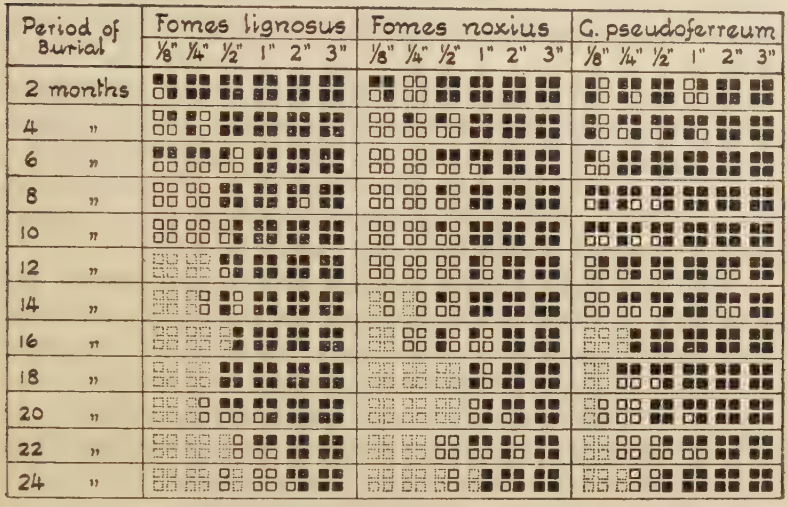

Figure 1. Survival of the parasites in diseased roots; the roots ranging in diameter from ⅛ in to 3 in, and in length from 1 ft to 2 ft. The results given by the shorter roots are shown on the left of each column.

It will be observed that the difference in rate of loss of infectivity between *Fomes noxius* and *Fomes lignosus*, which had been apparent after twelve months burial, was less evident after two years, and that *Ganoderma pseudoferreum* is still clearly the more persistent of the three parasites. Perhaps the most interesting point brought out by these observations so far is that—irrespective of which parasite is present—a relatively short piece of diseased root no more than two inches in diameter can remain infectious for at least two years.

Field study of the economics of root disease control (Experiment P 48. Inland Soil) — A third round of inspection and treatment has been carried out in the experiment laid down on Pataling Estates in 1948*, and a slight increase in the incidence of disease

* *Rep. Rubb. Res. Inst. Malaya* (1945-8) 142

has been noted. There are grounds for supposing that the low rate of incidence so far recorded in this experiment is not so much due to a lack of sources of infection as to the fact that only a small proportion of the old rubber stumps lie close to the replanted 'hedges'. It will be interesting, therefore, to see whether the incidence will rise markedly as the root systems of the young trees expand.

Evaluation of various methods of treating stumps for the control of root disease (Experiment G 50. Inland Soil) — The first part of the experiment laid down on Galloway Estate in 1950 (*Pathological Division '50* page 7), that is the study of the effect of various methods of poisoning on the rate of death of the stumps, was completed during the year.

Statistical analysis of the data has shown that treatment *A** brings about the death of the lateral roots at a rate which indicates that it is significantly more effective in this respect than the other four stump poisoning treatments which are being studied. It remains to be seen, however, whether this treatment will show a sufficient superiority in the second part of the experiment (which is concerned with the effect of the treatments on the subsequent incidence of root disease) to justify its higher cost.

Field experiment on the control of root disease prior to and following replanting (Experiment CI 51. Coastal Soil) — A particularly comprehensive experiment occupying an area of 96 acres was established on Carey Island during the year. This experiment has been designed to achieve two objects; the first being to compare the value, from the point of view of root disease control, of various methods of disposing of the old stand; and the second to study the economics of root disease control in the replanted stand. It is thus, in part, complimentary both to the experiment on Galloway Estate (G 50) and to that on Pataling Estate (P 48).

The layout and treatments are as follows:

(*a*) The total area of 96 acres divided into *2 blocks* of 48 acres each

(*b*) Each of the 2 blocks divided into *4 sub-blocks* of 12 acres each

Sub-block (Preplanting) Treatments

4 treatments x 2 replications

A Taproot and laterals of old stand to remain whether diseased or healthy

---

* *15 oz of sodium arsenite in the form of a 10 lb: 1 gallon solution introduced through one-inch auger holes bored from the outside of the stump inwards and downwards over the laterals*

B Diseased trees on the margins of open patches to be removed

C All diseased trees to be removed

D All trees, whether diseased or not, to be removed

(*c*) Each of the 8 sub-blocks divided into *3 plots* of 4 acres each

Plot (Postplanting) Treatments

3 treatments x 8 replications

G Eradication based on detection of the disease by periodic tree to tree inspection in the young stand

R Eradication based on detection of the disease by the appearance of symptoms in the foliage of the young stand

Y No eradication; dead or dying trees to be removed with the minimum of disturbance

(*d*) 18 of the 24 plots divided into *8 sub-plots* of $\frac{1}{2}$ acre each. The 6 plots omitted are those in sub-blocks *D* where the old stand has been completely removed.

Sub-plot (Preplanting) Treatment

8 treatments x 18 replications

1 Old stand felled; stumps drilled and poisoned with sodium arsenite

2 Old stand felled; stumps ring barked and poisoned with sodium arsenite

3 Old stand felled; sodium arsenite applied to the fissure left on the cut surface of the stump

4 Old stand felled; cut surface of stump treated with a proprietary wood preservative

5 Old stand felled; soil round bole of stump treated with soil fumigant

6 Old stand felled; stump left *in situ* untreated

7 Old stand left, but ring barked and poisoned

8 Old stand left, but frill girdled and poisoned

All the preplanting treatments had been completed by the end of the year. A summary of their cost is presented in TABLE II.

I(3) INFLUENCE OF SAPROPHYTIC MICRO-ORGANISMS ON THE INCIDENCE OF ROOT DISEASE

Fungi antagonistic to Fomes lignosus — The interest in this subject arises from the fact that there are grounds for supposing that the activities of *F. lignosus* (and of the other root parasites) may be

checked, under natural conditions, by the competition of certain common saprophytes, these occurring either in the soil or on moribund plant tissue; and, this being so, that some of the agricultural operations practised on rubber estates can influence the prevalence of root disease indirectly by their effect on the distribution of these antagonists.

TABLE II: EXPERIMENT CI 51. SUMMARY OF THE COSTS OF THE PREPLANTING TREATMENTS

Average daily wage: $2.55

Cost of materials

Sodium arsenite: $70.50 *per cwt*

Soil fumigant: $14.00 *per gallon*

Wood preservative: $ 3.50 *per gallon*

(*a*) *Cost per acre of the Sub-block Treatments*
Means of 24 acres

Sub-block	*Labour*	
	Man-days	$
A	—	—
B	6.2	15.81
C	6.4	16.32
D	134.1	341.96

(*b*) *Cost per acre of the Sub-plot Treatments*
Means of 9 acres

Sub-plot	*Labour man-days*	*Materials* $	*Total* $	*No. of trees per acre*	*Cost per point* $
1	89.5	17.36	245.61	68.8	3.57
2	87.3	6.62	229.23	70.0	3.27
3	79.5	16.16	218.89	64.1	3.41
4	81.1	6.30	213.11	65.1	3.27
5	72.3	9.12	193.49	59.2	3.27
6	84.5	—	215.48	70.4	3.06
7	1.8	5.75	10.34	55.2	0.19
8	3.0	16.55	24.20	51.2	0.47

In this regard the practice of growing a ground cover at once comes to mind. Evidence indicating that the incidence of root disease tends to be reduced in the presence of a ground cover was obtained before the war. The explanation then offered was that the roots of the cover plants reduced the 'collective vigour' of the

rhizomorphs of the parasites by causing them to break up into small units (Annual Report for 1933, page 109). What is now thought to be the more likely explanation is that the presence of a ground cover maintains the soil in a condition which favours the development of micro-organisms which are antagonistic to the root parasites.

In 1948 some evidence had been obtained which indicated that *Trichoderma viride* (a common soil saprophyte) was antagonistic to *Fomes lignosus* (Annual Report for 1948, page 148). During the course of the year under review the study of this problem was re-opened, observations being made on *Trichoderma viride,* and on two other organisms, *Botrydiplodia theobromae* (a ubiquitous invader of moribund plant tissue) and a species of *Ceratostomella* which is frequently found colonizing the recently cut surface of the stumps of felled rubber trees. Attention was directed to *B. theobromae* because it was thought that the facility with which it establishes itself in tissues rendered moribund by a variety of causes implies that it possesses a very effective mechanism for dealing with competitors; and the *Ceratostomella* was chosen for investigation because of its habitat, which would enable it to play an important part in controlling the dissemination of *F. lignosus* by airborne spores, were it antagonistic to the parasite.

So far the results obtained with *B. theobromae* and the *Ceratostomella* have been inconsistent, both organisms having given evidence of the production of an antibiotic substance in one series of experiments but not in subsequent trials. There is however reason to think that this inconsistency was due to a change in the composition of the medium on which the organisms were grown.

On the other hand, the antagonism of *Trichoderma viride* to *F. lignosus* was confirmed, as is shown by the data presented in TABLE III below. In the experiment to which this table refers, a nine days old culture of the *Trichoderma* on Richard's solution was filtered through paper and the filtrate then divided into two parts, one of which was sterilized in the autoclave and the other by passage through a porcelain bougie. A set of eight potato dextrose agar plates each containing 10 ml of medium and 2 ml of sterile filtrate was then prepared from the two samples. Eight plates containing 2 ml of fresh Richard's solution were set up as controls. Each plate was then inoculated at its centre with *F. lignosus.* The results shown TABLE III were obtained after five days' growth.

TABLE III: INHIBITION OF THE GROWTH OF F. LIGNOSUS BY CULTURE FILTRATES OF TRICHODERMA VIRIDE

Medium	*Diameter of F. lignosus colonies in mm (Means of 8 replicates)*	*Differences from control means*	*S.e. of differences of means*
P-d agar + 20% culture filtrate sterilized by heat	25.19 (S.e. ± 2.50)	16.62	± 3.06
P-d agar + 20% culture filtrate sterilized by ultrafiltration	28.25 (S.e. ± 2.41)	13.56	± 2.98
P-d agar + 20% Richard's soln. (Control)	41.81 (S.e. ± 4.98)	–	–

II

DISEASES OF THE TAPPING PANEL

II(1) MOULDY ROT (CERATOSTOMELLA FIMBRIATA)

There was a noticeable decrease in the number of inquiries received during the year on the subject of mouldy rot. It would be unwise to infer from this that there was any marked reduction in the prevalence of this disease. Indeed the more likely explanation is that the majority of planters are now familiar with the measures which should be taken for its control. It is evident from the data supplied by the Smallholders' Advisory Service that there was little change in the incidence of mouldy rot on smallholdings, since the disease was again observed to be present in about 8% of those inspected during the year.

Treatment of wounds resulting from mouldy rot — The experiment started in 1950 has now been completed, and has been of considerable interest in showing that the wounds caused by mouldy rot (which normally remain open) can be induced to heal over provided they are given suitable treatment. The petroleum grease, S/V Product 2295-C, yielded the best results, followed closely by a cowdung and clay mixture. Asphalt and kerosene wound paint, Skene's Pruning Mixture, and Mouldos in plam oil were much less satisfactory.

DISEASES OF THE TAPPING PANEL

II(2) BLACK STRIPE (PHYTOPHTHORA PALMIVORA)

Bark fissures as a subsidiary symptom -- The development of longitudinal fissures in the renewing bark of trees of clone P.B. 86 on an estate in Negri Sembilan has been shown to be the result of an attack of black stripe. The fissures occurred some distance above the tapping cut, and dissection disclosed that they had developed in association with characteristic black stripe lesions in the wood. The disease was still active at the time of inspection, and the pathogen (*Phytophthora palmivora*) was isolated from primary lesions situated immediately above the tapping cut.

The particular interest of this observation lies in the fact that fissuring of the renewing bark has not previously been regarded as a symptom of black stripe.

II(3) EVALUATION OF FUNGICIDES

Examination of cationic detergents -- The following cationic detergents have been subjected to preliminary *in vitro fungicidal* tests against the pathogen of mouldy rot:

Cetyl pyridinium chloride
Lauryl pyridinium chloride
Cetyl dimethyl benzyl ammonium chloride
Mixed alkyl dimethyl benzyl ammonium chloride
Stearyl dimethyl benzyl ammonium chloride.

All except the last named (which was not fully effective below 0.05%) were found to be capable of inhibiting the growth of the fungus at a concentration of 0.01%.

Field trials against mouldy rot — Field trials of the two organomercurial preparations (R. 1412 and R. 1489) referred to in last year's report (page 12), and of two coal tar dyes were carried out on an estate in Selangor. Fylomac 90 was included in the test as a standard. The results are given in TABLE IV.

In view of the promise it had shown in previous *in vitro* tests (Annual Report *Pathological Division '50*, TABLE IV) the results given by brilliant green are most disappointing. Observations in the field indicate that the dye does not adhere too well to the cortical tissues, being rapidly leached away even by a light shower.

The performance of both the organomercurials was good; the one formulated as a dispersible powder (R. 1412-157) being almost as effective as Fylomac 90. There is still some doubt however whether the higher concentration at which these two prepartions were tested (*i e* 1.0%) is not too close to the phytotoxic limit to

be safe for general use. A further investigation of this point is to be carried out.

Official tests — A proprietary tar acid emulsion, which had been submitted for examination with a view to its inclusion in the official list of fungicides approved for the treatment of mouldy rot, was given a field test. It was rejected for two reasons, namely instability of the emulsion and failure to give adequate control except at a phytotoxic concentration.

TABLE IV: ASSESSMENT OF FUNGICIDAL EFFICACY AFTER 14 APPLICATIONS

Fungicide	*Concentration (per cent)*	*Efficacy (100=complete control)*
Fylomac 90	0.28	100*
Brilliant green	1.00	16
	0.10	12
Crystal violet	2.00	64
	1.00	32
R. 1412-157	1.00	100†
	0.50	100‡
R. 1489-81	1.00	100‡
	0.50	67

* *Reached after 7 applications*
† *Reached after 8 applications*
‡ *Reached after 11 applications.*

III

SECONDARY LEAF FALL

During the main period of refoliation, which extended until late in May, outbreaks of secondary leaf fall were reported from every State and Settlement in the Federation excepting Kelantan, Trengganu and Pahang. In this regard it is of interest to record that whilst the disease is known to have occurred in Kelantan and Pahang in recent years, it has not been reported from Trengganu since the war.

The attack appears to have been extremely mild, only fifty-nine outbreaks being brought to our notice. Dsitribution was as

given in TABLE V. The majority of these outbreaks occurred in April. Ten more outbreaks of secondary leaf fall were reported after the main period of refoliation was over, eight during July and two during August, seven of which occurred in Johore and the remainder in Negri Sembilan. Clone Tj. 1 was involved (with other clones) in five of these.

TABLE V: DISTRIBUTION OF KNOWN OUTBREAKS OF SECONDARY LEAF FALL

State or Settlement	*Outbreaks*
Kedah & Perlis	18
Penang & P. Wellesley	6
Perak	8
Selangor	6
Negri Sembilan	9
Malacca	8
Johore	4

III(1) STUDIES ON THE ASSOCIATED PARASITES

Observations on the incidence of the parasites — Examination of 149 representative specimens forwarded for confirmatory diagnosis yielded the information in TABLE VI concerning the incidence of the four parasites associated with the main annual epidemic of secondary leaf fall. It is difficult to say whether the increase in the incidence of *Scirtothrips dorsalis,* which has been recorded over the last three years, is actual or due merely to the introduction of an improved method of examination.

TABLE VI: INCIDENCE OF THE PARASITES ASSOCIATED WITH 149 CASES OF SECONDARY LEAF FALL

Parasite	*Percentage of cases in which*	
	Present	*Unassoctd**
Oidium heveae	90	18
Hemitarsonemus latus	69	1
Gloeosporium alborubrum	20	1
Scirtothrips dorsalis	15	nil

** i e unassociated with any of the other three parasites*

Observations on Oidium heveae — So far we have been unable to confirm the observation, recently reported from Ceylon*, that

*YOUNG, H.E. *Quart. Circ. Ceylon Rubb. Res. Scheme* 26 (1950) 13

Euphorbia hirta L is an alternate host for *Oidium heveae*. During the course of an examination of a number of plants of this common weed, one was found bearing a species of *Oidium* morphologically similar to *O. heveae*, but it was not possible to infect *Hevea* leaves of a susceptible age with the spores of this fungus. Furthermore, all our attempts to infect the *Euphorbia* with *Oidium heveae* have been unsuccessful.

A Coccinellid beetle which feeds on *Oidium heveae*, both in the larval and adult stages, has been identified as *Thea bistigmosa* Muls.

IV

LEAF DISEASES OF YOUNG PLANTS

Observations made at Sungei Buloh have shown that both the clones recently introduced from Indochina (IR. 7 and OE. 1) are susceptible to attacks by *Helminthosporium heveae* and *Gloeosporium alborubrum*.

IV(1) BIRD'S EYE SPOT (HELMINTHOSPORIUM HEVEAE)

A full account of the work on this disease that has been in progress since September 1948 has now been published*.

Mycological Studies

Influence of various environmental factors on growth in culture — Further studies have been made of the influence of light and of the substrate on the form of growth assumed by *H. heveae*.

Heat resistance of the conidia — Additional observations on the effect of high temperature on the viability of the spores of *H. heveae* have confirmed their remarkable resistance to dry heat.

Pathological Studies

Dissemination of the disease — The sudden appearance of very heavily infected plants in a somewhat isolated nursery of seedlings, which at the time were bearing few sporulating lesions, raised the question of the origin of this infection. It was considered that it might have come either from some plant other than *Hevea*, or from leaf mould or other organic material on which the fungus was growing saprophytically. Investigation failed to disclose any alternate host, but laboratory experiments have shown

*HILTON, R.N. *J. Rubb. Res. Inst. Malaya* 14 (1952) 40

that *Helminthosporium heveae* can grow saprophytically in competition with other organisms on such material as soil, dead *Hevea* leaves and bark, and dead lalang leaves.

Conditions favouring infection — The way in which a rubber leaf reacts to infection by *H. heveae* has been shown to be dependent on three conditions, namely: its age; the age of the plant that is bearing it; and (for young plants) whether it has developed under conditions of full insolation or not*.

Acquisition of resistance by the maturing leaf has been found to be due to changes in the character of the cuticle, but the more unusual phenomenon—the marked difference in susceptibility that exists between sun and shade leaves—is still unexplained and has now become the subject of investigation.

During the course of this study it has been determined that these two classes of leaf differ rather strikingly in respect of the tannins which they contain, the tannin content of shade leaves consisting mainly of catechol tannins and that of sun leaves of gallotannins.

This finding suggested that the resistance to *H. heveae* which is characteristic of shade leaves might be associated with their content of catechol tannins; a subsequent observation indicating that catechol tannins are present in the brown margins which delimit the typical *Helminthosporium* lesion on a sun leaf added weight to this conception. However no supporting evidence has yet emerged from a study of the effect of various gallo and catechol tannins on the growth of *H. heveae* in culture.

Factors affecting sporulation — The tendency for sporulation to be confined to the underside of the leaf has been shown by experiment to be independent of the influence of light and of gravity. An observation made at Sungei Buloh suggests that the production of spores may be affected by the moisture content of the soil on which the host is growing. Further indications have been obtained that lesions arising from primary infections sporulate more freely than those subsequently formed, suggesting that infection may produce a degree of immunity.

Investigations on Control Measures

Comparison of spraying techniques—The experiment was primarily designed to determine to what extent our failure to obtain satisfactory control of bird's eye spot with any of the fungicides tested in the past could be attributed to their use at too low a concentration, or to the method or frequency of application employed.

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The experiment was laid down in the Smallholders' nursery at Sungei Buloh in six blocks, each containing four plots (2 methods of application x 2 fungicides). Each plot was further divided into seven sub-plots (3 frequencies x 2 concentrations + 1 control). The area of each sub-plot was 1/240 acre. The height of the seedlings was recorded at the start of the experiment and again on its completion fourteen weeks later, the increment in height being used as a basis for assessment. The treatments studied were as follows:

Concentration of fungicide	*Perenox* at 5 lb and 10 lb per acre *Bordeaux mixture* at 3:4 and 6:8 lb per acre
Method of application	*High volume*: 60 gal per acre at 80 p s i using Hymatic H. P. S. 2/T unit, and Eclipse lance with No. 3 disc nozzle *Low volume*: 10 gal per acre at 15 p s i using the same Hymatic unit but fitted with an Aeraspray No. 77 atomizing spray gun
Frequency of application	At intervals of 3, 5 and 7 days, resulting in 32, 19 and 14 applications respectively

From a statistical analysis of the results it has been possible to draw the following conclusions:

(*a*) that Bordeaux mixture is superior to Perenox.

(*b*) that failure to secure adequate control of the disease with the fungicides tested is not due to their being used at too low a concentration.

(*c*) that applications made at the rate of 10 gal per acre and 15 p s i are as effective as those made at 60 gal per acre and 80 p s i.

(*d*) that reducing the interval between applications has a distinctly beneficial effect.

(*e*) that although no marked effect is visible to the eye, spraying with copper fungicides undoubtedly results in improved growth.

In vitro tests of fungicides — The fungistatic value of a number of compounds has been re-examined by the slide germination method. Spersul, a wettable sulphur which had not previously been tested, gave 100% germination at a concentration of 0.1%.

Trial of systemic fungicide — A small scale field trial was carried out with 2,4,6-trichlorophenoxyacetic acid, a substance

which has been reported to possess the characteristics of a systemic fungicide. One year old seedlings growing in an infected nursery were used for the test. The 2,4,6-T was applied in solution in amounts ranging from 0.2 to 0.5 gm per plant. Application was made in two ways, by pouring the solution round the base of the plant and by spraying it over the leaves. Neither method of treatment appeared to affect the course of the disease.

Search for resistant planting material — The possibility of controlling bird's eye spot by the use of resistant planting material is constantly borne in mind. Tests carried out in 1949 showed that *Hevea brasiliensis* x *spruceana* hybrid seedlings possessed no resistance. More recently it has been found that *Helminthosporium heveae* is capable of infecting both *Hevea spruceana* and *Hevea benthamiana*. However, inoculation experiments have shown that the latter species reacts less severely to such an infection than *Hevea brasiliensis*.

IV(2) GLOEOSPORIUM LEAF SPOT (GL. ALBORUBRUM)

Influence of the substrate on growth in culture — A study has been made of the form and rate of growth of *Gloeosporium alborubrum* on ten agar media. The observations were confined to isolates from clone B.D. 5. The numerical data obtained were submitted to statistical analysis. Judged by the rate of growth and intensity of sporing, potato dextrose agar and yeast extract glucose agar proved to be the most suitable media.

Evaluation of fungicides — A preliminary examination of the fungistatic value in respect of the spores of *Gl. alborubrum* of eight proprietary fungicidal dusts has been made by means of the slide germination technique. An aqueous extract of potato dextrose agar was added as a stimulant to the spore suspensions used in these tests. The fungicides tested were S.S. Sulphur, Perelan, Spergon, Phygon, Dithane Z-78 (70% zineb), Vitospor ZX (5% ziram), Vitospor FX (5% ferbam) and 100% thiram.

Taking into account the concentration of active ingredient present in these fungicides the results given by Vitospor ZX (5% zinc dimethyl dithiocarbamate) and Vitospor FX (5% ferric dimethyl dithiocarbamate) were considered the most promising.

The previous observations on the ineffectiveness of sulphur were fully confirmed.

It was established by means of a further experiment that the fungistatic value of zinc dimethyl dithiocarbamate (ziram) was

superior to that of zinc ethylene bisdithiocarbamate (zineb) and tetramethylthiuram disulphide (thiram).

Studies on the Gloeosporium-Colletotrichum complex — Work on *Gl. alborubrum* and related fungi which are pathogenic to *Hevea* has been hampered by failure to distinguish between the various forms on the basis of spore measurements. The absence of a perithecial stage (and our inability to induce the formation of one in culture) make classification even more difficult. Striking differences in the appearance of the lesions produced on *Hevea* leaves by certain of the components of this complex makes us hesitate to accept the view that they represent a single species (*i e Glomerella cingulata*). Steps are therefore being taken to see whether it is possible to distinguish the various forms on the basis of their mode of growth in culture.

IV(3) OTHER LEAF DISEASES OF YOUNG PLANTS

A hitherto undescribed disease caused by a species of Colletotrichum — A detailed study has been made of the leaf disease associated with a species of *Colletotrichum* whose spores are produced not only in acervuli but also terminally on the setae (Annual Report *Pathological Division '49*, page 31). This fungus may occasionally be found occupying the same lesion as *Helminthosporium heveae* and, when first observed, was on this account mistakenly thought to be a secondary infection. However experimental inoculations have now demonstrated that it is unquestionably parasitic.

A paper embodying a full account of this disease has been published*.

Cercospora sp. — A species of *Cercospora* has been observed occurring in association with a leaf spot of nursery seedlings.

V

DEFENCE AGAINST SOUTH AMERICAN LEAF BLIGHT

In view of the fact that the conclusion of a general Phytosanitary Convention for the South East Asia and Pacific Region was likely to be further delayed, it was suggested by the Government of the United Kingdom that, as an interim measure, the rubber growing countries in this area might be invited to consider the adoption of a series of regulations designed to prevent the introduction of

*JOHN, K.P. *J. Rubb. Res. Inst. Malaya* 14 (1952) 11

South American leaf blight into the region. Accordingly a draft agreement embodying these regulations was prepared and submitted for consideration.

During the year, in accordance with the agreement reached in 1950 and in exchange for a selection of Malayan planting material, a number of *Hevea* clones, resistant to *Dothidella,* intended for introduction into this country, were despatched by the Director of the Instituto Agronomico do Norte at Belem to the U.S.D.A. Quarantine Station at Coconut Grove, Florida. Here, with the kind cooperation of the U.S. Department of Agriculture, they are being grown under observation before being forwarded to Malaya *via* the Commonwealth Mycological Institute at Kew.

V(1) METHODS OF ERADICATION

Evaluation of Herbicides and Defoliants

Comparison of the n-butyl esters of 2,4-D and 2,4,5-T — The conclusions reached last year as to the relative effectiveness of the n-butyl esters of 2,4,5-T and 2,4-D as defoliants for rubber were based on experiments carried out in the field against nursery seedlings. It seemed desirable, however, that these observations should be checked by the use of a more precise method of assessment; and with this object in view the two compounds were compared in an experiment in which the solutions under test were applied, with the aid of a specially designed spray tower, under strictly standardized conditions to young seedlings in pots.

Each compound was tested at four concentrations (1.0%, 0.5% 0.25% and 0.125%) in four solvents (Shell Diesoline, Mobil Penetrating Oil, P.Y. Sovacide, and Shell Aromatic Gas Oil). The thirtytwo solutions were applied in duplicate at the rate of 1 ml per plant. It was so arranged that only the leaves and stems of the plants were exposed to the spray. Immediately after treatment the plants were placed in the open.

The superiority of 2,4,5-T as a herbicide for use against rubber seedlings was fully established by this experiment, thus confirming the results obtained in the previous year. Of the 32 seedlings that had been sprayed (and defoliated) with the 2,4-D solutions all but three were still alive two months later, whereas at the same date all but four of the 32 plants that had been treated with the 2,4,5-T solutions were dead.

Although in general symptoms of injury appeared earlier in plants sprayed with the 2,4,5-T solutions made up in P.Y. Sovacide, the type of oil used as a solvent seemed to have little ultimate effect on the results obtained with this material, and Shell

Diesoline has therefore been chosen as the solvent for use in all future experiments because it is more readily available that the others.

Evaluation of the non-volatile esters of 2,4-D and 2,4,5-T — The non-volatile beta-n-butoxyethyl esters of 2,4-D and 2,4,5-T have been compared with the volatile n-butyl esters in respect of their herbicidal activity against rubber. The order of increasing activity was found to be as follows: volatile ester of 2,4-D; non-volatile ester of 2,4-D; non-volatile ester of 2,4,5-T; volatile ester of 2,4,5-T.

Evaluation of other compounds — The following compounds have been tested for their herbicidal value against rubber and have been found to be less effective than the n-butyl ester of 2,4,5-T:

n-butyl 4-chlorophenoxyacetate
3,6-endoxotetrahydrophthalic acid
disodium 3,6-endoxohexahydrophthalate.

Observations on translocation — Observations on translocation were made on young seedlings in pots. The method consisted

TABLE VII: TRANSLOCATION OF HERBICIDES

Herbicide	*Effect*
2% *n-butyl* 2,4,5-T	*Marked signs of translocation in 3 days. Defoliation by 16 days and death in 4 weeks*
2% *disodium* 3,6 *endoxo hexahydrophthalate*	*No signs of translocation. Treated leaflet shed by 16 days*
2% 3,6-*endoxotetra-hydrophthalic acid*	*Signs of translocation in 7 days. Defoliation by 17 days and death in 4 weeks*
2% *n-butyl* 4-*chlorophenoxyacetate*	*No signs of translocation. Treated leaflet shed by 16 days*
2% *beta-butoxyethyl* 2,4,5-T	*Signs of translocation in 10 days. Treated leaflet shed by 16 days and remainder by 4 weeks. Death in 6 weeks.*

in cutting off the tip of one leaflet and then immersing the cut leaflet in the herbicide under test for half an hour. The treatments were carried out in duplicate. The results are given in TABLE VII.

Incorporation of a Fungicide in the Defoliant Solution

The whole object of our work on herbicides has been to select a material which could be used if necessary for checking the spread of South American leaf blight by defoliating the area of infection. But as the fungicidal value of the 2,4,5-T solutions it is proposed to use for this purpose is in doubt, it has been considered desirable to add pentachlorphenol to them to increase their activity in this respect. The presence of pentachlorphenol tends, however, to increase the rate of defoliation, with the result that the leaves may fall before the 2,4,5-T has had time to be translocated. Experiments were therefore carried out to determine the maximum concentration of pentachlorphenol that could be incorporated in the 2,4,5-T solutions without reducing their herbicidal activity, and this was found to be in the neighbourhood of 0.5%.

Test against Mature Trees

As the selection of a suitable herbicide had been based on tests carried out against young seedlings, clearly the next step was to determine whether the selected material would be equally effective when used against mature trees. This immediately raised a problem, because there appeared to be no low volume sprayer available of suitable design to cover a tall tree. Nevertheless, an attempt was made to overcome this difficulty by operating a small mist blower from rising ground. Two tests were carried out by this means. In the first of these, the trees were sprayed with a 0.25% solution of n-butyl 2,4,5-T in Shell Diesoline. Coverage was poor and little defoliation occurred. In the second trial the concentration of the 2,4,5-T was increased to 2.0%, and this led to a considerable improvement in results. The two trees that caught most of the drift were almost completely defoliated, and remained in this condition for over two months. Furthermore there was evidence that an appreciable amount of die back had been induced, since when refoliation did occur it arose from dormant buds situated some way below the tips of the branches.

In view of the conditions under which this experiment was conducted, it is of course not possible to say at what rate the application was made in terms of gallons per acre. On the other

hand it is known that the drops which made up the spray were well below the size that can be used effectively in spraying from aircraft. Thus the experiment can be regarded as providing no more than an indication of the sort of result that may be expected when the defoliant is sprayed from the air.

Experiments on the Dissemination of a Defoliant from the Air

It was announced during the course of the year that the Government of the Federation was proposing to purchase a number of de Havilland Beaver aircraft for use on a feeder service which was to be operated in conjunction with the Malayan Airways' Dakotas. In the light of this information, the suggestion that we should employ a Dakota for our experiments on the dissemination of a defoliant from the air was reconsidered, and at a meeting held in October under the chairmanship of the Director of Civil Aviation it was agreed that, in view of the superior manoeuvrability of the Beaver and of its ability to operate from fairly primitive airstrips, the experimental work should be carried out with this type of aircraft in preference to a Dakota. In consequence of this decision, a formal approach was made to the Government for permission to use one of its Beavers for this purpose in May and June 1952.

V(2) PROCEDURES TO ENSURE FREEDOM FROM DISEASE OF IMPORTED PLANTING MATERIAL

Observations on the disinfection and packing of seed — An experiment has been undertaken in collaboration with the Botanical Division on the disinfection and packing of Hevea seed. The object of this experiment was to study the effect on the subsequent germination of the seed of:

(*a*) the moisture content of the powdered charcoal used as packing material,

(*b*) the type of container employed (wooden box or sealed tin)

(*c*) disinfection with Agrosan GN

(*d*) the nature of the storage atmosphere (air or nitrogen).

These four factors were combined in eighteen treatments, each of which was replicated three times on lots of 50 seeds. After packing the seed was stored for 3 weeks and then set out for germination. A control was set out for germination at the time of packing. Details of the treatment and the percentage germination recorded after 20 days are shown in TABLE III.

TABLE VIII: EFFECT OF DISINFECTION AND VARIOUS METHODS OF PACKING ON THE GERMINATION OF HEVEA SEED

Treatments					Germination after 20 days, %
No.	Charcoal % moisture	Type of container	Disinfection	Storage atmosphere	
1	15	Sealed tin	Agrosan GN	Nitrogen	98
2	15	„ „	Agrosan GN	Air	99.3
3	15	„ „	Nil	Nitrogen	98
4	15	„ „	Nil	Air	98
5	15	Wooden box	Agrosan GN	Not sealed	80
6	15	„ „	Nil	Not sealed	80
7	25	Sealed tin	Agrosan GN	Nitrogen	98
8	20	„ „	Agrosan GN	Air	100
9	20	„ „	Nil	Nitrogen	98.6
10	20	„ „	Nil	Air	100
11	20	Wooden box	Agrosan GN	Not sealed	95.3
12	20	„ „	Nil	Not sealed	96
13	25	Sealed tin	Agrosan GN	Nitrogen	98.6
14	25	„ „	Agrosan GN	Air	97.3
15	25	„ „	Nil	Nitrogen	98
16	25	„ „	Nil	Air	99.3
17	25	Wooden box	Agrosan GN	Not sealed	100
18	25	„ „	Nil	Not sealed	98.6
19	Control — No treatment				8

Treatments 17 and 18 (25% moisture and wooden boxes) gave excessive germination during storage. The control seed (treatment 19) required 58 days to reach 89.3% germination.

VI

STEM AND BRANCH DISEASES

VI(1) PINK DISEASE

Ten outbreaks of pink disease, seven of which had occurred in stands of rubber under four years of age, were brought to our notice during the year. The monthly returns received from the Smallholders' Advisory Service continued to indicate that the disease was not prominent in smallholdings. This may well be due to the fact that these cultivations still contain only a very small proportion of young rubber.

Fungicidal value of Fylomac 90 — In vitro tests have shown that Fylomac 90 (90% tetradecylpyridinium bromide) is fungicidal against *Corticium salmonicolor* at a concentration of 0.28%. As a result of this finding Fylomac 90 is being recommended for use in the treatment of pink disease on young trees.

VI(2) PATCH CANKER

No case of injury which could be regarded as being due to patch canker has been encountered since 1948. Indeed the opinion is growing that — as Sharples suggested many years ago — the condition known as 'patch canker' is no more than a sequel of lightning damage. It has become abundantly evident over the last few years that when the cortical tissues of rubber are injured by lightning, they are (for reasons which are quite unknown) almost invariably invaded by species of *Pythium.*

VI(3) DISEASES OF YOUNG SHOOTS

None of the cases of die back of young shoots which was brought to notice during the year could be attributed to the intervention of a parasite.

VII

INJURIES OF NON-PARASITIC ORIGIN

Of the fourteen cases of injury of non-parasitic origin whose cause was diagnosed during the year, eight were found to be due to sodium arsenite poisoning. Sun scorch, lightning and fire accounted for the remainder.

Our advice was sought in seventeen cases of malicious wounding by terrorists, which in the aggregate involved many thousands of trees.

Treatment of wounds resulting from malicious damage — A large scale trial of wound dressings was carried out in Field 42 of the R.R.I. Experiment Station where some 1,200 ten year old bud-grafted trees were ring barked and slashed by terrorists on the night of 10-11 June. In this experiment the two preparations—S/V Product 2295-C and the asphalt and kerosene mixture — which had given the best results in the previous year's trials (Annual Report *Pathological Division '50* page 26) were compared with three petroleum greases (Shell Ensis 352, Shell Otina C, and Shell Unedo 3) and three bitumen solutions (Shelmac R.C. 2, Colas B, and Shell P.F. 4) submitted by the Shell Company. A compound of S/V Product 2295-C and a fungicide, marketed by the Standard Vacuum Oil Company under the name of 'Tree Fungus Cure', was also included in this test.

Each treatment was applied to three rows of trees, and periodic observations were made on the rate of bark regeneration. The final assessment of performance (TABLE IX) was carried out six months after application of the dressings, by which time the two best had induced complete regeneration of the bark, even on trees from which it had been stripped for a height of 5 to 6 feet from the graft union.

TABLE IX: ASSESSMENT OF WOUND DRESSINGS

Order of Merit	*Dressing*
First	*S/V Product 2295-C* *S/V 'Tree Fungus Cure'* *Shell Ensis 352*
Second	*Shell Otina C*
Third	*Shelmac R.C. 2* *Asphalt and kerosene mixture*
Fourth	*Colas B* *Shell PF. 4*
Fifth	*Shell Unedo 3*

The following conclusions have been drawn from this experiment:

(*a*) that the three petroleum greases, S/V P 2295-C, Shell Ensis 352 and Shell Otina C, are suitable for the treatment of slashed trees;

(*b*) that bitumen solutions are inferior as wound dressings to these three greases;

(*c*) that Shelmac R.C. 2 may be substituted for the asphalt and kerosene mixture where use of the latter mixture is indicated;

(*d*) that the incorporatiton of a fungicide in S/V P 2295-C is without observable effect.

VIII

TERMITES

VIII(1) ECOLOGICAL STUDIES

Incidence of termite attacks on smallholdings — The monthly returns of the Smallholders Advisory Service, while not exactly a census, do provide the only information we have of the general pattern of infestations throughout the country. Data relating to the incidence of termites during the last four years are summarised, by States and Settlements, in TABLE X.

TABLE X: PERCENTAGE OF SMALLHOLDINGS VISITED BY RUBBER INSTRUCTORS WHERE TERMITE ATTACKS WERE REPORTED

State or Settlement	*% attacked*			
	1948	*1949*	*1950*	*1951*
Kedah & Perlis	4.32	2.95	2.02	1.10
Penang & P. Wellesley	2.27	4.30	3.03	2.04
Perak	1.36	1.18	1.30	1.77
Selangor	0.92	0.40	0.13	0.22
Negri Sembilan	2.23	2.31	2.94	2.33
Malacca	7.66	5.78	4.86	4.09
Johore	0.84	0.30	0.76	0.35
Pahang	5.08	2.96	1.81	0.47
Trengganu	1.53	0.21	nil	0.19
Kelantan	0.27	2.08	1.99	0.63
Mean % incidence	2.26	1.46	1.30	0.97

In comparing the figures in this table it is necessary to make allowance for personal factors, which will be most liable to affect the records for those States or Settlements (Penang and Province Wellesley, Trengganu, Kelantan) which are served by only one Instructor and where the numbers of holdings visited in a year are

accordingly fewer (averaging less than 1000). It is seen that the picture is one of diminishing attacks over successive years. There are also considerable differences, for which no explanation is offered, between the various territories.

VIII(2) OBSERVATIONS ON CHEMICAL CONTROL

Evaluation of routine control measures — In the past it has been assumed that to leave untreated a field which was exposed to termite attack was to invite heavy tree losses. For this reason, and because such losses are particularly to be avoided on the R.R.I. Experiment Station (where most of the fields are devoted to long term investigations), until now no attempt had been made to assess the effectiveness of the insecticides used in the routine methods of control by comparing them with a treatment in which no chemical was employed. However, on the understanding that some form of chemical treatment would be introduced on the first signs of accelerated losses, the use of insecticides has been discontinued in Field 34* since the beginning of February, and treatment has been restricted to brushing down the mudwork as it appears. In the meanwhile the control measures previously employed in Fields 30 and 33 are being continued. Thus, given sufficient time, it should be possible to determine with a fair degree of accuracy the practical value of mercuric chloride and white arsenic as insecticides for use against *Coptotermes curvignathus*.

Up to the end of the year the incidence of attack in Field 34 had remained normal.

Protection of newly planted stumps — An experiment was laid down in October 1950 to determine whether stumps planted in an area heavily infested with termites could be protected by incorporating a small quantity (2 oz) of an insecticide with the soil of the planting hole. The insecticides tested were a 5% D.D.T. dust, Agrocide 2, and 5% Toxaphene dust. These three and the control treatment were evenly spread over the area, every four successive plants receiving one of the treatments. As losses occurred, supplies were planted and given the same treatment as the stumps which they replaced.

The incidence of termite attack during the five succeeding months is shown in TABLE XI, from which it is apparent that none of the treatments exercised any protective value. It is of course

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* *Field 34 had been under the crater method of treatment (employing Cymag and sodium silicofluoride) during the course of the comparative study described in Pathological Division '50 (page 27)*

possible that the failure of all three insecticides was due to the low concentration at which they were employed, but the concentrations used in the experiment were decided by considerations of cost.

TABLE XI: INCIDENCE OF TERMITE ATTACK ON STUMPS RECEIVING INSECTICIDAL TREATMENTS AT PLANTING

Records for five months

Treatment	*No. of stumps in treatment*	*Percentage attacked*
5% *D.D.T.*	340	11.2
Agrocide 2	338	12.1
5% *Toxaphene*	340	16.8
Control	337	12.8

IX

COCKCHAFERS

THE ONLY CASE OF COCKCHAFER ATTACK encountered during the year was a recrudescence of the outbreak reported as occurring in a nursery in Selangor in 1950.

X

MITES

X(1) BIOLOGICAL STUDIES

Tetranychid mites — Of the four Tetranychid mites known to feed on rubber leaves, three have been identified by the Commonwealth Institute of Entomology as species of *Paratetranychus*, the fourth being a species of *Eutetranychus*.

Pseudoleptid mites — A second species of *Brevipalpus* found on rubber leaves has been identified by Mr E.W. Baker of the U.S. National Museum as *B. phoenicis* Geijskes. Neither this species nor the one previously reported (*B. australis* Tucker) is of economic importance.

X(2) INVESTIGATION OF CONTROL MEASURES

Trial of a systemic insecticide — The systemic insecticide Pestox 3H has shown some promise in preliminary tests against the

yellow tea mite (*Hemitarsonemus latus*). One application of a dilute solution, applied either by spraying the leaves or watering the soil, was sufficient to eliminate *H. latus* breeding on young seedlings in the insectary. The time taken to bring about a complete kill (up to 24 days) varied with the concentration used, which ranged from 0.15% to 0.6% by volume.

XI

OTHER INSECT PESTS

ORTHOPTERA

Grasshoppers — *Catantops splendens* was responsible for causing considerable damage to a newly planted nursery of clonal seed in Johore.

HEMIPTERA

Coccids — A locally severe outbreak of the scale insect *Lepidosaphes cocculi* was observed on an estate in Selangor, the attacked plants being two year old buddings of P.B. 86.

Association of Coccids with malformations — A further case of fasciation associated with the presence of a mealybug came to notice during the year.

COLEOPTERA

Boring beetles — An unusual case of borers attacking healthy trees was observed on an estate in Selangor on Clone A.V 152 planted in 1929. In every instance the attacked trees had lost a large branch low down, and the beetles were breeding in the dead wood of the stub. It would appear that from there they had proceeded to attack the stem, where they concentrated on the tapping panel as being the most vulnerable part. While some had succeeded in penetrating the healthy bark, their burrows extended only to a slight depth in the wood. Control was effected by pruning off dead branches and applying a dressing to the attacked region on the stem. The beetles have been identified as *Xyleborus interjectus.*

LEPIDOPTERA

A pest of lalang — A caterpillar feeding on lalang (*Imperata cylindrica*) in Johore has been identified as the larva of a Noctuid moth, *Laphygma exempta.*

XII

NEMATODES

AGAIN NO CASE OF INJURY DUE TO EELWORMS was encountered although, as consequence of the replanting which is taking place all over the country, large areas of leguminous cover crops are now in existence. It is possible that the leguminous species now in particular favour—*Centrosema pubescens* and *Pueraria phaseoloides*—are less susceptible to these parasites than were some of those formerly cultivated.

XIII

OTHER ANIMAL PESTS

Damage to young plants caused by rats, squirrels, porcupine, pigs, deer, monkeys, and snails and slugs received attention during the year.

Leaf Monkeys — A rather unusual form of leaf injury which occurred on an estate in Johore is thought to have been caused by monkeys of the genus *Presbytis.*

Experiments on slug and snail baits — Attractancy and durability tests have been carried out with various formulations of the lime cement snail bait bricks whose preparations was first described in the Annual Report for 1948, page 188. In one series of tests the bricks reduced the snail population of four locations where they were successively placed, and were still catching snails on the 36th day. The most durable formulation was still in good condition after nine months in the open, but attractancy tests have not yet been made after such a prolonged exposure.

XV

ROOT NODULE BACTERIA

Distribution of Rhizobium cultures — A total of 380 cultures of *Rhizobium* were sent out to planters and agricultural stations during the year for the inoculation of cover crop seed. The principal demand was for strains effective on *Centrosema pubescens* and *Pueraria phaseoloides.*

Studies on cross inoculation — A number of cross inoculation experiments have been carried out with *Rhizobium* strain No. 272,

which was isolated in 1950 from *Pueraria phaseoloides*. More limited studies have been made with two other strains, namely, No. 30 (isolated in 1947 from *Flemingia congest*) and No. 261 (isolated in 1950 from *Centrosema pubescens*). The results obtained are shown in TABLE XII. It is of interest to observe that the three strains tested were all capable of inducing beneficial nodulation on cowpea (*Vigna sinensis*), but failed to nodulate soya bean (*Glycine soja*).

TABLE XII: RESULTS OF CROSS INOCULATION WITH THREE LOCALLY ISOLATED STRAINS OF RHIZOBIUM

Test Plant	*Strain No. 272*	*Strain No. 30*	*Strain No. 261*
Calapogonium mucunoides	+		
Cassia occidentalis	−	−	−
Centrosema plumierii	−		+
Centrosema pubescens	+	*	
Clitoria laurifolia	−		
Crotalaria anagyroides	−		
Crotalaria striata	+		
Crotalaria usaramoensis	+		
Desmodium ovalifolium	+		
Flemingia congesta	−	+	
Glycine soja (*soya bean*)	−	−	−
Leucaena glauca	−		
Mimosa invisa	−		
Mimosa pudica	−		
Phaseolus aureus (*green gram*)	+	+	−
Pueraria phaseoloides	+		−
Tephrosia candida	−		
Tephrosia vogelii	+		
Uraria crinata	−		
Vigna sinensis (*cowpea*)	+	+	+

+ = beneficial nodulation induced
** = nodulation abnormal*
− = not nodulated

Growth in litmus milk — In an endeavour to determine the relationship of the three strains referred to above, a study was made of their characteristics in litmus milk (TABLE XIII). To what extent it is justifiable to regard these results as denoting specific differences is perhaps open to question, but on the basis of the

classification given in Bergey's Manual (6th Edition)*, the data presented above would indicate that strain No. 272 belongs to the species *B. meliloti,* and that strains Nos. 30 and 261 represent either *R. lupini* or the unnamed cowpea organism. The inability of the latter two strains to nodulate soya bean at least implies that they are not *R. japonicum.*

TABLE XIII: CHARACTERISTICS OF THREE STRAINS OF RHIZOBIUM IN LITMUS MILK

Strain	*Serum zone*	*pH after 70 days*	*State of litmus*
No. 30	*absent*	7.73	*normal*
No. 261	*absent*	8.06	*normal*
No. 272	*present*	5.61	*reduced*

New Isolations — Six new isolations of strain No. 272 have been made after passage through *Centrosema pubescens* (Nos. 338, 339, 340), *Pueraria phaseoloides* (*Nos.* 341 *and* 342), and *Crotalaria striata* (No. 343).

ADVISORY WORK AND OTHER ACTIVITIES

THE NUMBER OF LETTERS DESPATCHED from the Division during the year was 767. Specimens sent in for examination reached a total of 292. The graduate staff of the Division paid 55 visits to estates and smallholdings and 96 visits to the Experiment Station. Interviews at the Institute numbered 70.

Circulars and leaflets — The following circulars and leaflets were issued during 1951:

Treatment of Wounds	Circular No. 32
Pink Disease	Circular No. 33
Bird's Eye Spot	P/AL. 7(51)

R.A. ALTSON
Head of Pathological Division

Kuala Lumpur
August 1952

* BREED, R.S., MURRAY, E.G.D. and HITCHINS, A.P. *Bergey's Manual of Determinative Bacteriology* 1948